INNOVATIE NU

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04

REALISATION OF INTELLIGENT PRODUCTION

A MESSAGE FROM THE EDITOR

We would like to acknowledge and thank the support from the following organisations:

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A reality that exists in our minds – different from the external physical world – was first described by Immanuel Kant almost 250 years ago. Today, the concept is still used to describe a world that is not tangible, but that our mind can clearly perceive.

Various ways exist to digitally manipulate a person's perception of reality. The easiest by adding elements to the existing world, a technique that is called Augmented Reality (AR). An example of this is a tour of a shopfloor, where information is projected directly onto the machines and shows information about efficiencies or (upcoming) maintenance work. By completely substituting the reality of the user with a digitally generated one, Virtual Reality (VR) is created.

Recently, the potential of AR and VR has been discovered by the manufacturing sector. But the full potential has not been reached or implemented so far. In the new age of manufacturing, businesses and industries have had to re-evaluate safety and efficient production and methods of service, ranging from utilising online video conferences to shutting down physical operations entirely. Technologies such as remote working solutions have never been more important, but alternate, advanced technologies such as Augmented Reality and Virtual Reality are seeing expanded opportunities as well.

For Kant, virtual reality was something that only existed in our minds, but nowadays virtual realities have practical applications that forward-thinking manufacturers are already taking advantage of and make the invisible visible. As described by Morpheus in The Matrix: "You take the blue pill...the story ends, you wake up in your bed and believe whatever you want to believe. You take the red pill...you stay in Wonderland, and I show you how deep the rabbit hole goes." So perhaps its time for manufacturers to escape from their world of ignorance and confined comfort and take their red pill to awaken from illusions and see the hidden potential within the organisation.

GIJS BEUMKES

Research Engineer
Fraunhofer Project Center
at the University of Twente

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InnovatieNU Team

Editor-in-chief
Ian Gibson

Managing Editor
Gijs Beumkes

Management
Azlina Azman
Annemiek Rouchou-Bloemenkamp

Design
Ale Sarmiento Casas

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MPDV

Serious VR B.V.

Smart Production Solutions

Contact details
Fraunhofer Project Center
University of Twente – Horst Building
Drienerlolaan 5
7522 NB Enschede
The Netherlands

T: +31 (0)53 489 9255
E: media-fpc@utwente.nl

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CONTENTS

KICK-STARTING AI IN PRODUCTION

APPLICATION AREAS, PUBLICLY AVAILABLE DATA SETS AND SUCCESSFUL IMPLEMENTATION

Author:

Jonathan Krauß

Head of Department
Production Quality
Fraunhofer Institute for
Production Technology IPT

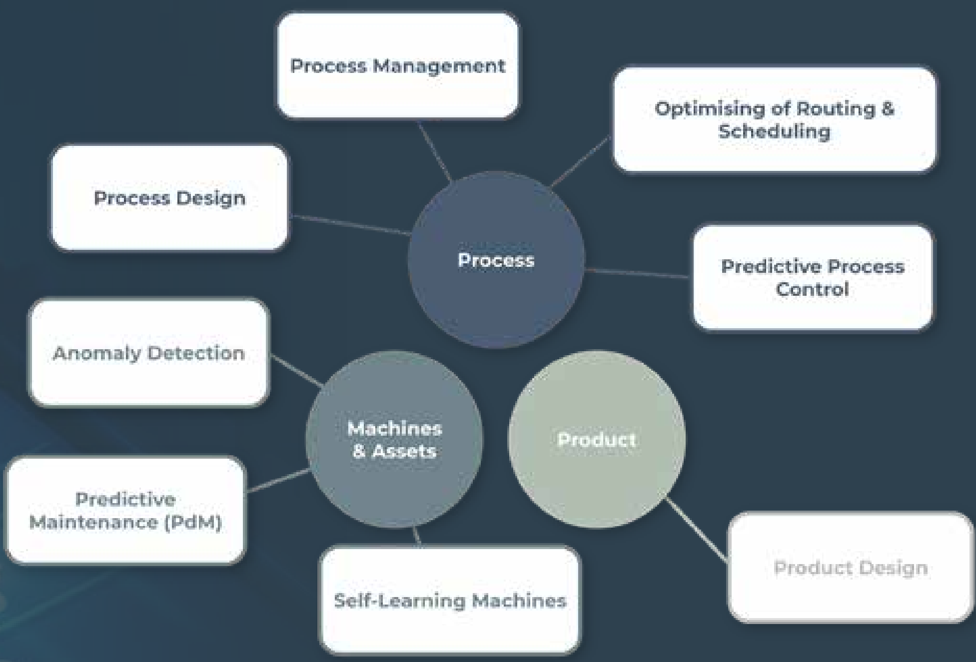

Figure 1: Overview of the application areas Process, Machines & Assets and Product. Below, application areas are located in production and circumscribed with applications. [3–5, 7–11, 13]

Increasing computing power and better data bases with simultaneously decreasing costs for computing and storage capacities represent the basis for the use of Machine Learning (ML) in production. As a result, ML methods are increasingly being used in production. ML methods can be used to train artificial intelligence (AI) systems, which the majority of companies hope will increase their productivity [1]. Challenges on the path to AI systems in in-house production include identifying promising application areas, recognising the associated learning tasks, and uncovering suitable data sets.

Application areas for AI and ML in production

The decision to apply ML in production is made for a wide variety of reasons and by different people in charge. In some cases, it is the process owner who wants to solve a specific problem. In others, it is the management level that wants to test the use of ML. In each case, the basis is the choice of the right application area in the company. Existing studies, which give an overview of possible application areas, often only consider partial aspects of modern production facilities. A high level of abstraction or a lack of topicality mean that these studies are only suitable to a limited extent for identifying the company's own problems. [2–13]

In order to provide a basis for the selection of a use case, the Fraunhofer IPT identified the application areas shown in Figure 1. These are based on our own studies as well as experience from industry and research projects. The use cases can be divided into three clusters: Process, Machines & Assets, and Product. Through the overview, new projects can be identified and starting points for data collection in production can be found.

In order to prioritise projects, it is necessary to assess whether the corresponding data basis is sufficient. This is possible if the project team is interdisciplinary and the employees have built up expertise in the field of data science. In addition to theoretical knowledge, the employees involved should have gained experience in the use of ML with concrete data sets.

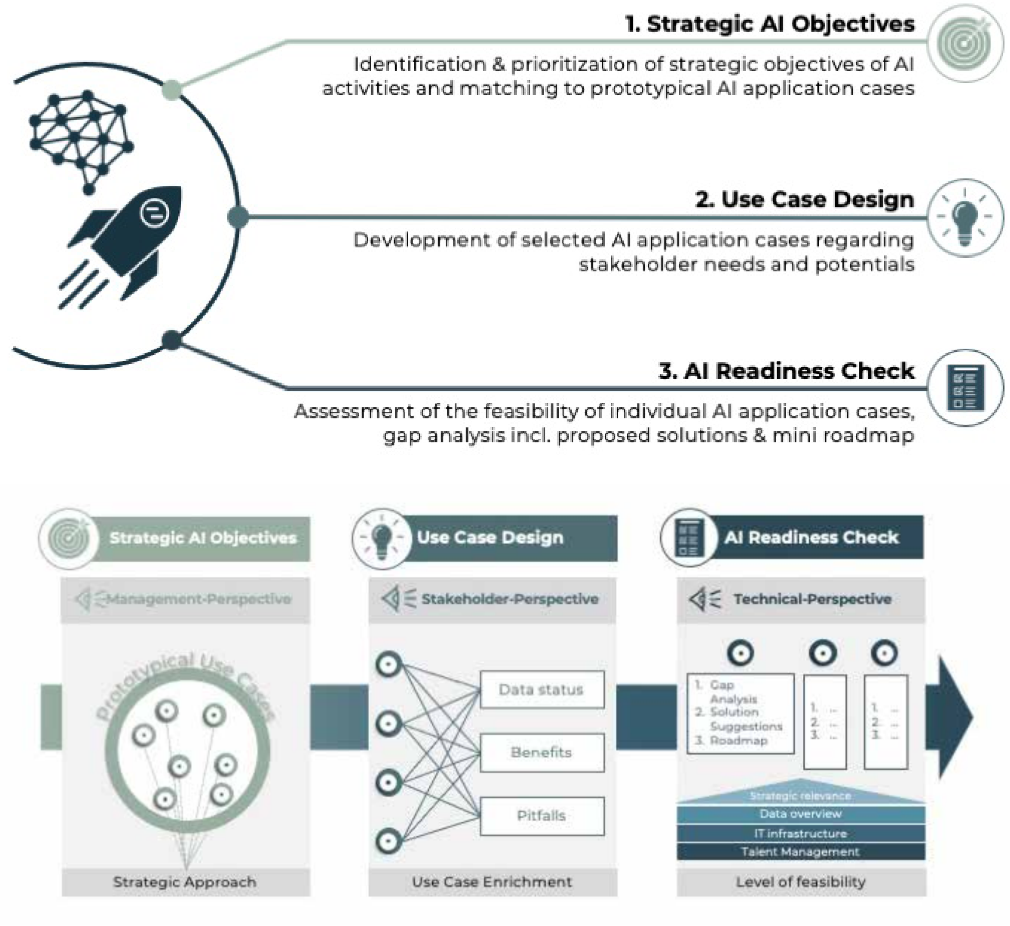

Figure 2: AI Kick-Starter Bundle of Fraunhofer

Data basis in production

The lack of experience of employees in dealing with AI and ML leads to the fact that the overwhelming number of ML projects fail despite increasing data volumes [14, 15]. One of the reasons for the lack of experience is that the company's internal data is unstructured, does not contain the relevant information or is not stored in sufficient quantity [16]. In these cases, it is possible to gain initial experience in the use of ML using freely available data sets. However, the data sets that are publicly available in the area of production are stored on different platforms.

For these reasons, publicly available data sets were elicited at the Fraunhofer IPT to gather initial experience with the focus on "production". These available data sets can be assigned to the application areas named above. The entire overview can be accessed via the link ipt.fraunhofer.de/ml-and-ai-in-production.

Apply AI and ML successfully

Once the application area has been defined and the necessary experience is available, a future challenge for companies will be to certify the processes and products in which the AI systems are used. The limited determinism of ML models will lead to a rethinking of the corresponding entities and will be actively shaped by the Fraunhofer IPT and the Fraunhofer Big Data AI Alliance [17–23].

In summary, the two biggest obstacles for companies at present are identifying the most promising AI use cases and realistically assessing the corresponding data basis. As described in the article, the corporate strategy should be to build up in-house expertise. In addition, it is a good idea to take the first steps on the way to an AI project together with external partners. The "AI Kick-Starter" service developed within the Fraunhofer society (see Figure 2) is an opportunity for companies to evaluate and prioritise their use cases in a targeted manner [24].

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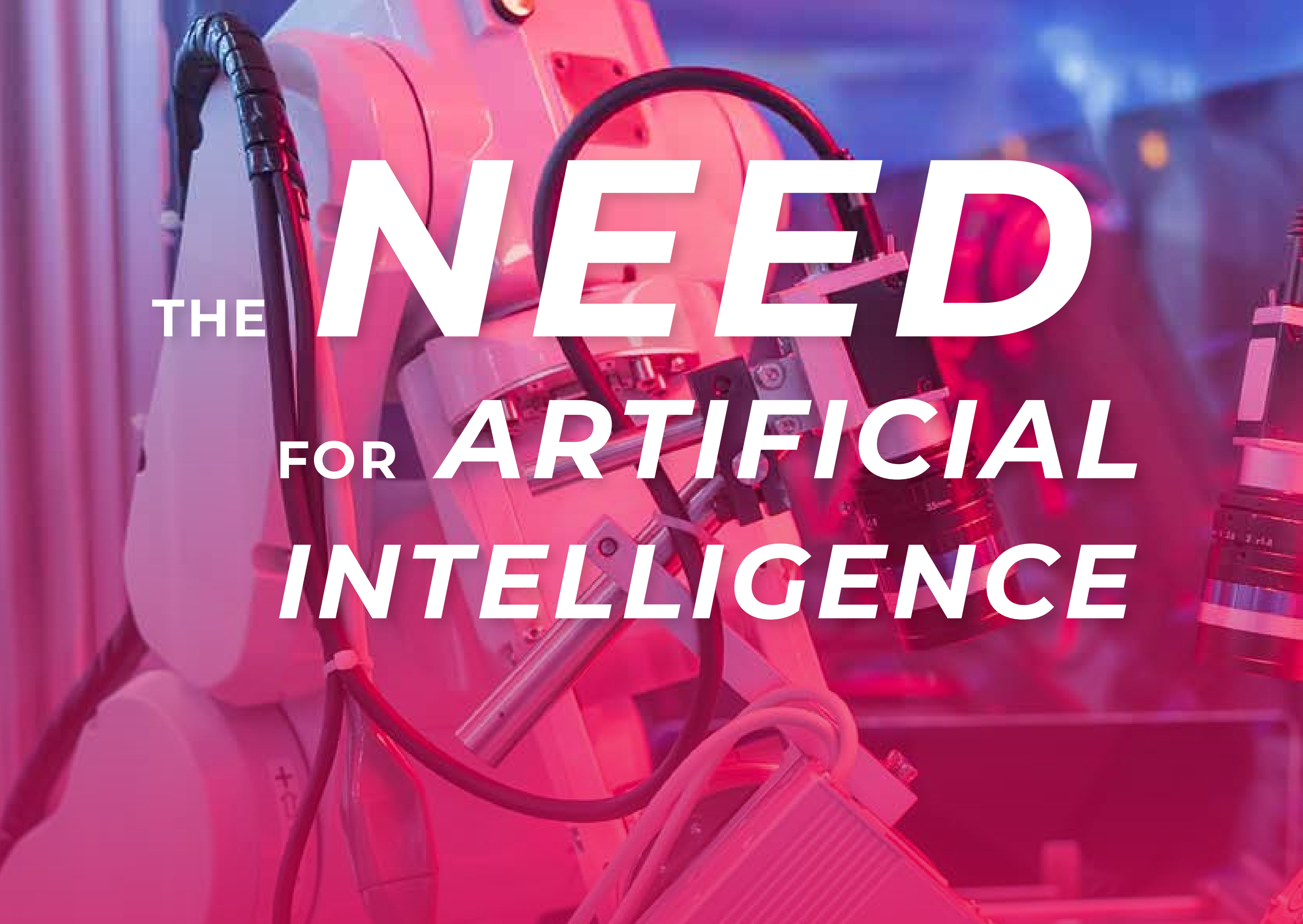


THE NEED FOR ARTIFICIAL INTELLIGENCE

Ever since the internet became a critical part of everyday life, the top factories have been digitising their operations. Now, digital technology is a widely used capability in every organisation, irrespective of size, providing vast amounts of information. However, there can be so many data available that many organisations are ill-equipped to use what is at their disposal.

Manufacturing companies face their own challenges. From defective product delivery to unexpected failure of machinery, there is a lot that can go wrong. This is where Artificial Intelligence (AI) comes in to give manufacturers the leverage needed to launch new products, enhance operational efficiency, and to personalise the designs of products and their corresponding services.

Manufacturing consists of analytical data, which machines are more capable of analysing compared to humans. Even in complex situations, machine learning models have proven to be effective at predicting the effects of individual variables.

Why is there an increased need for AI in manufacturing?

The true effectiveness of AI in manufacturing is still being realised. Capgemini conducted a study that included 22 uses cases in top manufacturing companies. It identified that intelligent maintenance, demand planning, and product quality inspection are the three key aspects of AI technology for manufacturers to use.

Including the likes of BMW and Canon, Capgemini covered various organisations that are using AI to enhance their production process. For example, the major cereal products producer, Kellogg's, is using AI for new product development. They launched a system to help customers pick out a recipe to make a product of their choice on their Bear Naked cereal bar website. The final products manufactured by the consumer giant are those that the customers wanted based on the AI algorithm's analysis.

IN THE *MANUFACTURING* INDUSTRY

There are numerous reasons why AI is readily being adopted by the manufacturing industry:

1. *To avoid frequent inspections from government and other regulatory bodies*
2. *Greater volatility of revenue streams makes it difficult to match products and processes to markets*
3. *Need to reduce costs*
4. *Need to reduce production times and increase efficiency*
5. *Increase adaptability and learning on the factory floor*
6. *Rising supply chain demands and manufacturing capacity can lead to increased risks for companies*
7. *There is a heightened requirement for personalised goods*

The benefits of AI to manufacturing industries

Increased safety

Being one of the riskiest industrial sectors, manufacturing is the reason behind an average of nine fatalities and 3,000 injuries each year across Europe. There is now plenty of evidence that shows if robots get involved in more complex and riskier tasks, unwanted accidents can be reduced, even when such tasks are semi-automated, human-centric environments. All of this is due to the benefit of AI monitoring, assessing, and predicting the potential risks.

Cost-Effectiveness

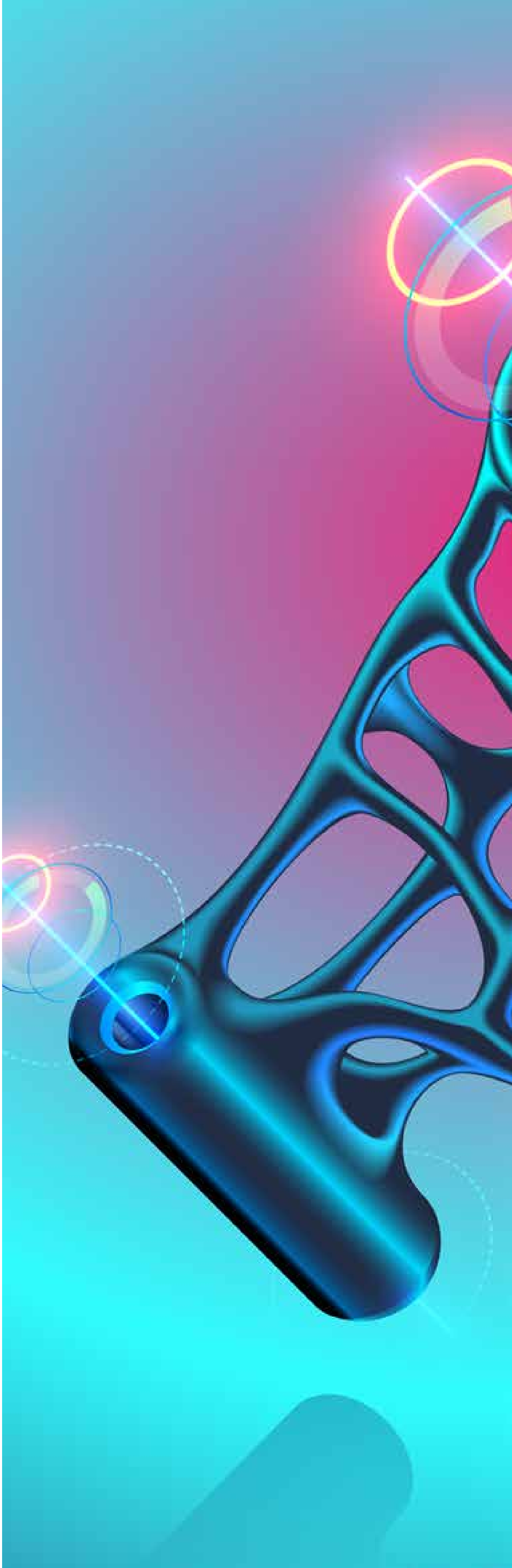
AI technology is effective when it comes to enhancing the analytics capability of an organisation, which allows it to efficiently allocate its resources, come up with better forecasts, and save on inventory costs. Due to the more advanced analytics capabilities at their disposal, businesses are also known to have made the jump towards predictive maintenance, thereby decreasing maintenance and downtime costs. In addition, operation costs are further saved by not having to pay out salaries.

Quality Assurance

Manufacturing is no easy task, and in order to produce fault-free products, each stage of the process should go as planned. Where once a skilled human was required to ensure the flawless manufacturing of goods, image processing and other sensor-based algorithms have taken over. The only requirement is the installation of sensors at critical points throughout the production process to make inspection automatic.

Quicker Decision Making

Due to the availability of a wide variety of Internet of Things (IoT) sensors, manufacturing companies can quite easily accumulate many terabytes of data and use real-time analytics to gain insights into how their products are made. Therefore, they are better equipped to make informed and quick decisions.



Generative Design

One of the lesser-known capabilities of an AI is in facilitating the development and design of products. A design engineer inputs the expected boundary conditions into a generative design algorithm, which will then analyse possible permutations and come up with a suitable design. Machine learning further helps in this process by testing various possible application scenarios to evaluate the viability of the design and suggest further improvements.

The likely results of implementing AI in manufacturing

By adopting various AI applications, manufacturing companies will be in a better position to do the following:

- **Detect defects as soon as they occur**
- **Enable predictive maintenance to decrease downtime**
- **Work on improving employee satisfaction by passing mundane tasks onto machines**
- **Validate the production of fault-free goods**
- **Reduce the costs of personalised goods, leading to the manufacturing of frequent single-run or small-batch products**
- **Effectively respond to changes in demand**

Digital Twins

Developing a digital twin of an already existing product and/or process means creating a virtual representation to gain valuable insight into it and experiment further. Connecting AI to a digital twin environment can be very useful to manufacturers in the following ways:

- **Product Development**
  Digital twins can additionally be used even before an actual product is manufactured. Thus, production companies can gather data and work on improving the physical counterpart.

- **Design Customisation**
  Since there is currently a high demand for customisation, manufacturers can utilise digital twins to produce multiple permutations of the same product. Thus, customers will be able to buy goods by accounting for performance metrics rather than making the decision based on the design alone.

- **Improvement in Shop Floor Performance**
  By using a digital twin, manufacturing companies can oversee and analyse the process of production to assure quality and identify where the performance is lagging. It enables manufacturers to receive clarity when it comes to input materials and automatically works out a solution.

Enhancing AI Adaptability in the Netherlands

In October of 2019, the Dutch Government released an action plan to enhance the global competitiveness of the Netherlands using AI. This plan was focused on three main pillars.

1. Development of policies to urge the adoption and implementation of AI in a wide array of private and public sector industries. In addition, the promotion of the use of AI was to be ensured when it came to taking on societal challenges.

2. Policies were to be devised to support the education and training in AI, leading to its advancement. Thereby, qualitative data could be attained, and digital infrastructure could be improved.

3. Policy actions could be increased, which would be in relation to some specific ethical issues, like human rights, the safety of citizens, consumer protection, and trust.

The strategy consisted of numerous initiatives, which would foster the growth of AI through various applications.

Conclusion

Artificial Intelligence has matured to a level where manufacturing industry can certainly benefit. Although there are some tried and tested applications, the majority of uses are still in the early adopter phase. However, as technology develops at an ever-increasing rate, it is important for manufacturers to at least be familiarising themselves with the possibilities and seriously considering plans for implementation. Costs, benefits, and ROI are still unclear but there is a definite need for upskilling and learning the relevant technologies. As is often the case, the costs incurred for not doing these things can be much higher.

THE ROLE OF

BIG DATA

AND

BUSINESS INTELLIGENCE

IN MANUFACTURING

Author:

Charles van der Pluijm

Account Manager
MPDV

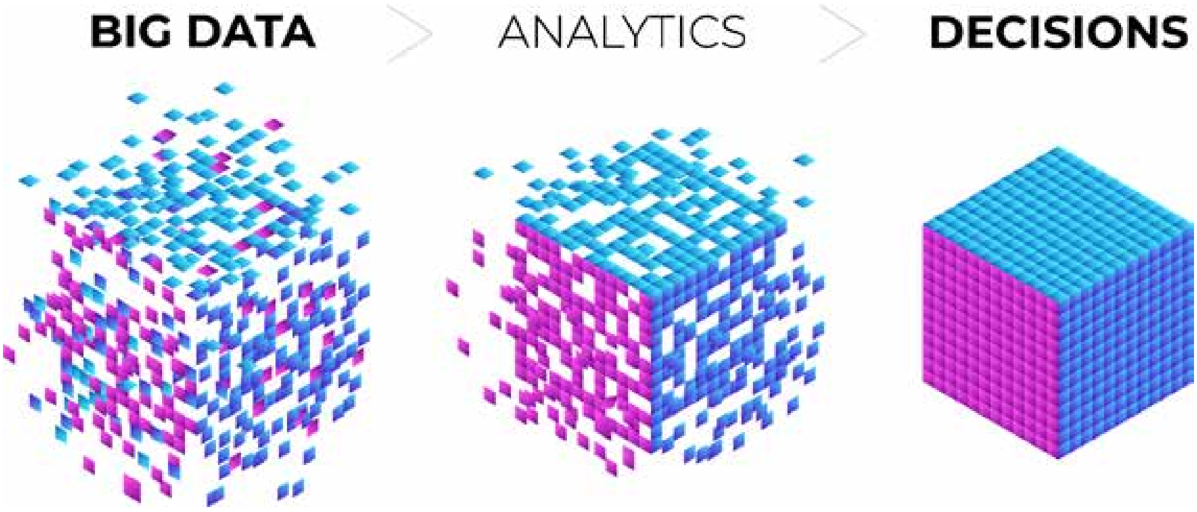
> *While data, regardless of its form or quantity, is a commodity, business intelligence refers to the process of turning it into insights.*

The manufacturing sector is lagging behind many others when it comes to the adoption of BI (business intelligence) systems. At the same time, manufacturers face a constant and growing pressure to innovate quickly in times of increasing economic uncertainty and an ever-greater emphasis on the importance of sustainability.

Leveraging big data has become a business imperative, not only in manufacturing, but every other sector as well. However, as the amount of digitisation continues to proliferate at a rapid pace, the challenge lies in translating the raw data into real-world use cases and actionable insights.

Seizing new market opportunities with innovative tech

The digital transformation of the manufacturing sector is dependent on the adoption of systems that generate valuable data, and that data is the fuel for BI systems. For example, IoT (Internet of Things) devices can collect data directly from the shop floor, without manufacturers having to rely solely on manual reports. Drones equipped with cameras and other sensors can record vast amounts of information across large areas in a fraction of the time that people can. These are just a couple of the examples of how innovative technology is feeding the big-data pipeline in modern manufacturing firms.



Building a scalable and extensible data foundation

The primary difficulty of leveraging big data for analytics is simply down to the fact there is so much of it. The amount of data being generated continues to double every two years, to the point data sets are now far too large for human comprehension. This is why modern BI tools have become heavily reliant on artificial intelligence and machine learning to translate the data into actionable insights.

Most manufacturers are still heavily reliant on their ERP (enterprise resource planning) tools, but while these systems are important, they are generally not geared up for big data analytics. In fact, ERP is itself a valuable data source, but it is one among many others, including RPA (robotic process automation), CRM (customer relationship management), and IoT systems.

To avoid missing or inaccurate insights due to incomplete data sets, data must be drawn from all of the sources that generate it. This requires a scalable and extensible framework that can be easily adapted to the constantly evolving needs of the organisation. Fortunately, the rise of open APIs (application programming interfaces) and industry-wide standards and protocols is making this easier, but many manufacturers still have a long way to go before fully realising their advantages.

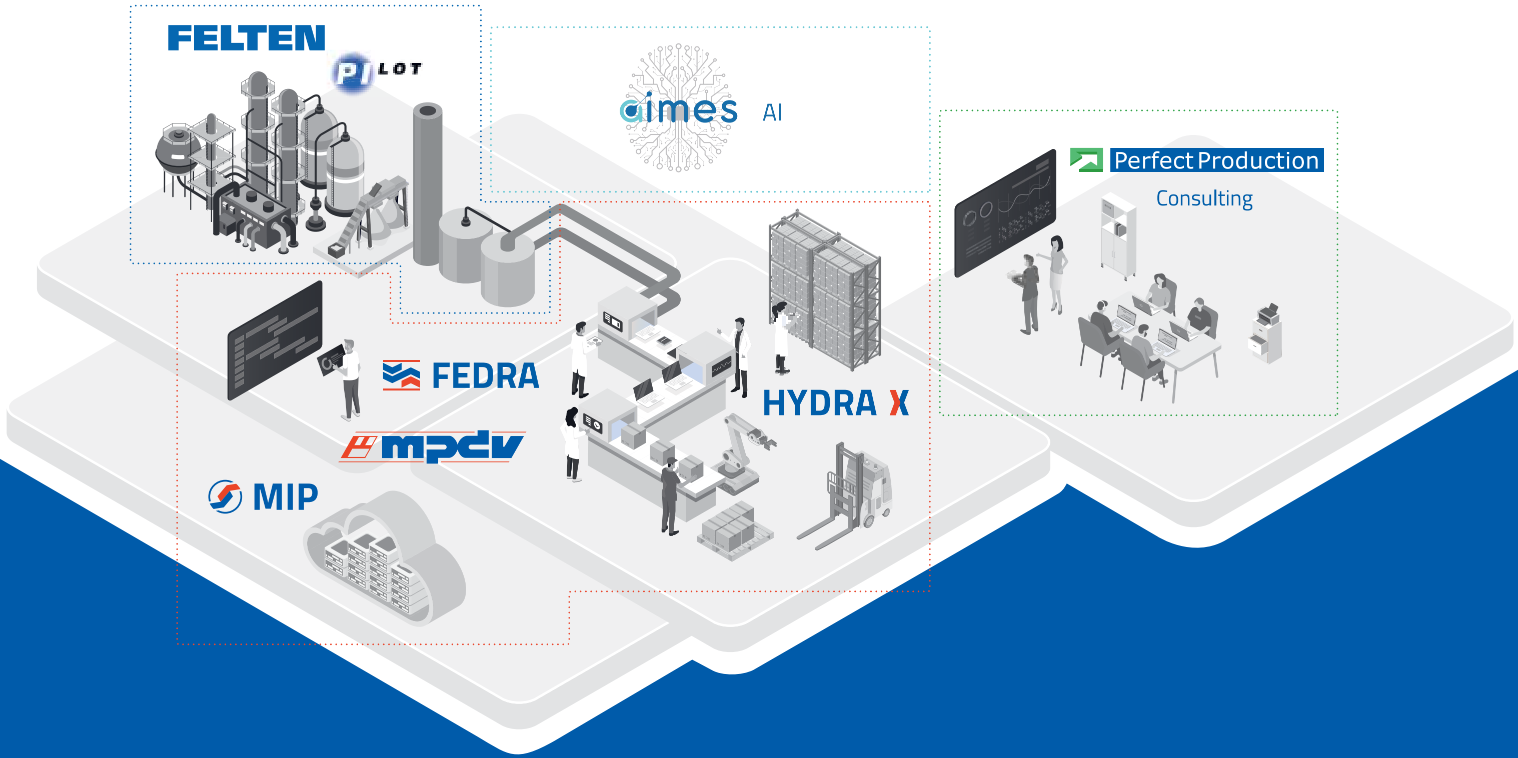
Gaining insights from new and existing data sources

Data collection is just the first part of the process. Big data is the fuel that enters the top of the BI pipeline, after which is goes through extensive analysis where data is curated, cleaned, and compared, before being released in the form of valuable information – or answers to the most pressing business questions, in other words.

While data, regardless of its form or quantity, is a commodity, business intelligence refers to the process of turning it into insights. These insights can enhance decision-making across the complete range of manufacturing operations from the predictive maintenance of machinery to insights for sales, marketing, customer support, and supply chain management departments. Together, this data-driven decision-making can reduce waste, improve products, and reduce cycle times.

Final words

Innovation does not happen in a bubble. In order to minimise risk and drive sustainable growth, the course of innovation must be driven by facts, rather than emotions and guesswork. This is enormously important in the manufacturing sector, where organisations often serve multiple markets and manage complex supply chains. Modern business intelligence systems, fuelled by the proliferation of big data, are critical for making that happen.



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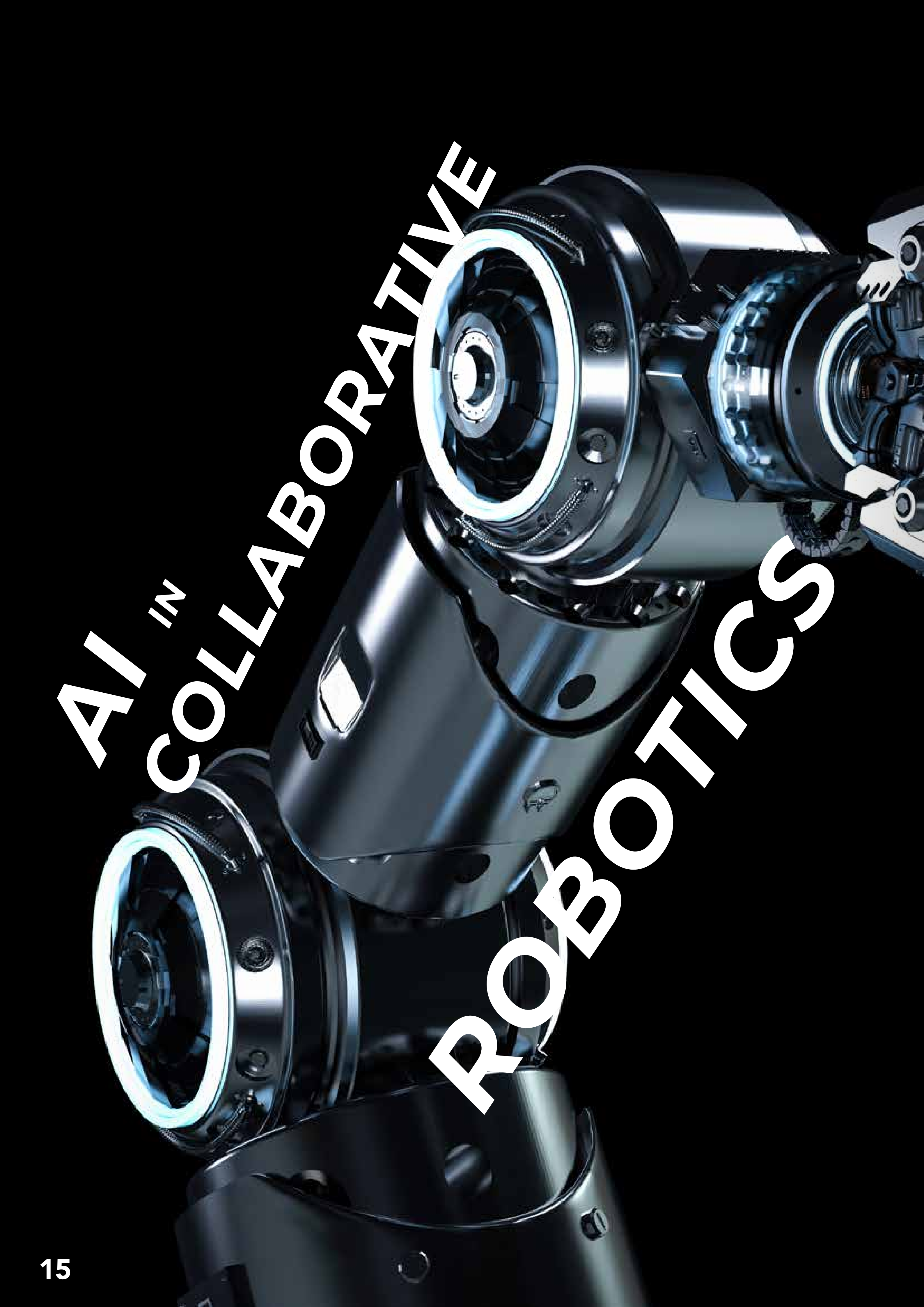


AI IN COLLABORATIVE ROBOTICS

> ***[...] each robot can perceive its environment and can adapt to changes - an ability that conventionally programmed manipulators exhibit only to a very limited extent.***

In the era of Industry 4.0, collaborative robots are one of the main pillars enabling flexible automation. In particular, dual-robot systems are increasingly seen as a promising trend of industrial automation for assembly and pick-and-place tasks. Dual-robot systems consist of two collaborating robot arms and offer advantageous characteristics. For instance, high redundancy can improve the flexibility in task manipulation, while synchronised manipulation can shorten the operation times.

To implement a dual-robot system, much of efforts are made on task planning. The two arms need to be synchronised to each other in time and space to avoid collisions and to improve the efficiency in terms of the operation time. Additionally, peripheral components as well as workpieces or workpiece positioners must be considered to define feasible trajectories, i.e. sequences of six-dimensional positions in Cartesian space, for both robot arms. To take advantage from dual-robot systems economically, the effort for task planning must be automated as well, in order to significantly decrease the set-up time. Following this idea, this work proposes an AI-based solution for a dual-robot system which enables autonomous trajectory planning for a given pick-and-place task by minimising the set-up time and by avoiding collisions.

A pick-and-place use case has been chosen as an illustrative example to verify the proposed algorithm. Within the use case, 16 cylindrical pins are palletised from a pallet to a turntable. The system consists of two KUKA KR 10 R1100 robots with six degree of freedom each. Both robots are equipped with two-finger grippers and share a common workspace. The system setup is shown in Figure 1.

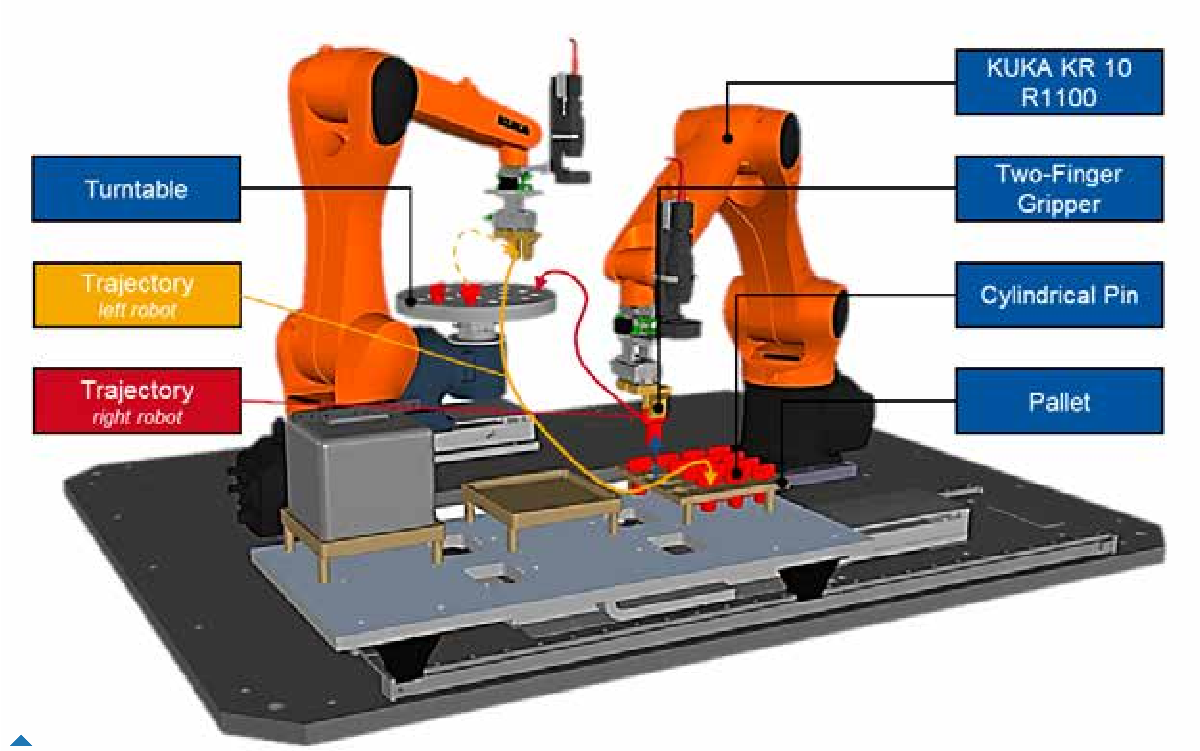


Figure 1: Components of the dual-robot system.

Problem Statement

The problem of robotic trajectory planning is the determination of six-dimensional pose sequences at a defined time step that the robot will approach with its tool center point (TCP) to perform a desired motion. On the one hand, robotic manipulation tasks generally exhibit a hierarchical structure. On the other hand, previous work demonstrates the suitability of AI-based trajectory planning for single robot setups. Our approach leverages and combines these two findings for multi-robot setups by designing a hierarchical control architecture that establishes a framework for multi-agent systems (see Figure 2 left): A superior manager logic supervises the fulfillment of the overall task and assigns subtasks to different specialised agents. Each individual agent is responsible for the trajectory planning of a particular robot at a particular time and is designed as a deep reinforcement learning (DRL) agent.

Approach

The goal is to train agents in dedicated simulation environment to acquire sub-task-specific skills utilising the reinforcement learning framework (see Figure 2 right). Accordingly, an agent receives information about the state of the robot in its working environment and, based on this, selects an action to move the robot in space. In this way, each robot can perceive its environment and can adapt to changes - an ability that conventionally programmed manipulators exhibit only to a very limited extent. In addition to the state and action space, a reward function needs to be defined that evaluates the agent's actions in form of a numerical reward signal. The underlying algorithm uses this signal to adjust its internal policy – a mapping from states to actions – that is represented by an artificial neural network. Based on this continuous perceive-act-and-adjust loop, the agent gradually optimises its trajectory planning in order to complete the sub-task in the most optimal manner regarding well-defined performance and quality criteria.

Once the required agents have been successfully trained, they are integrated into the conditional control structure that represents the multi-agent system. The resulting modular architecture of interchangeable and specialised agents is intended to foster the reusability of task-specific learning environments. The resulting ever-growing library promises to significantly reduce the development efforts for future multi-robot use cases.

Starting on the system architecture level, one result of the development process is a client server architecture that allows the communication between the Python learning environment, in which the manager logic and the intelligent control policies are implemented, and the robot simulation (see Figure 2 left). The client-server communication is responsible for sending the control commands to the simulation and for receiving the corresponding simulation responses. For the given dual robot use-case, the control structure includes two agents, one for each robot, that simultaneously palletise the cylindrical pins from the pallet on to the turntable. The learning environments in which the trajectory planners are trained are structured in the same way: The observation for each robot includes the Cartesian position of its TCP and a target position that represents either the pick or the place position of the currently considered pin. The action vector that is predicted by the artificial neural network is a six-dimensional Cartesian position command. The internal controller takes this command, performs inverse kinematics and drives the joints of the manipulator accordingly. Both robots are trained simultaneously in the same simulation to allow them to collaborate. The reward function that feedbacks evaluations of the taken actions to the agent, is designed to reward decreasing distances between TCP and target position as well as decreasing trajectory durations. As a result, the corresponding target positions are approached very time-efficiently, but the robots are also likely to collide with each other or with static objects within their workspaces. To avoid this highly undesirable behavior, a collision detection is further implemented and the corresponding digital collision signal is added to the reward function. By penalising collisions, the agents are explicitly trained to prevent undesirable contacts.

Results

Figure 3 shows the evolving reward signal over the course of approximately twelve hours of training: In the beginning, the reward is comparatively low and shows strong peaks. This is an indication that the agent is not yet able to complete the task and a large number of collisions occur. As training progresses, the reward increases, shows fewer peaks, and converges to the maximum total reward of zero. The fact that peaks still occur at later times is because of the agent's internal exploratory behavior, which is being disabled during operation.

The final tests in the simulation show that the two robots perform collision-free motions within their workspaces and need 86.14 seconds for palletising the 16 pins. In comparison to a single, manually teached-in robot, this is a 46 % improvement in terms of time. Thereby, it is demonstrated that simulation-based autonomous trajectory planning using reinforcement learning proves to be a promising alternative to conventional teaching, which for such more complex

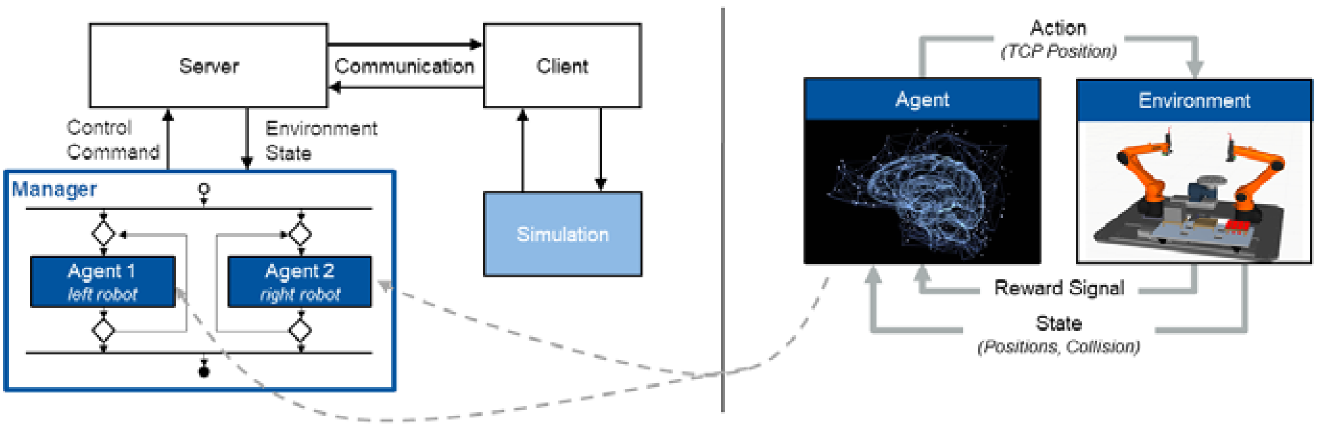


Figure 2: System architecture and manager-agent structure (left) and deep reinforcement learning control loop (right)

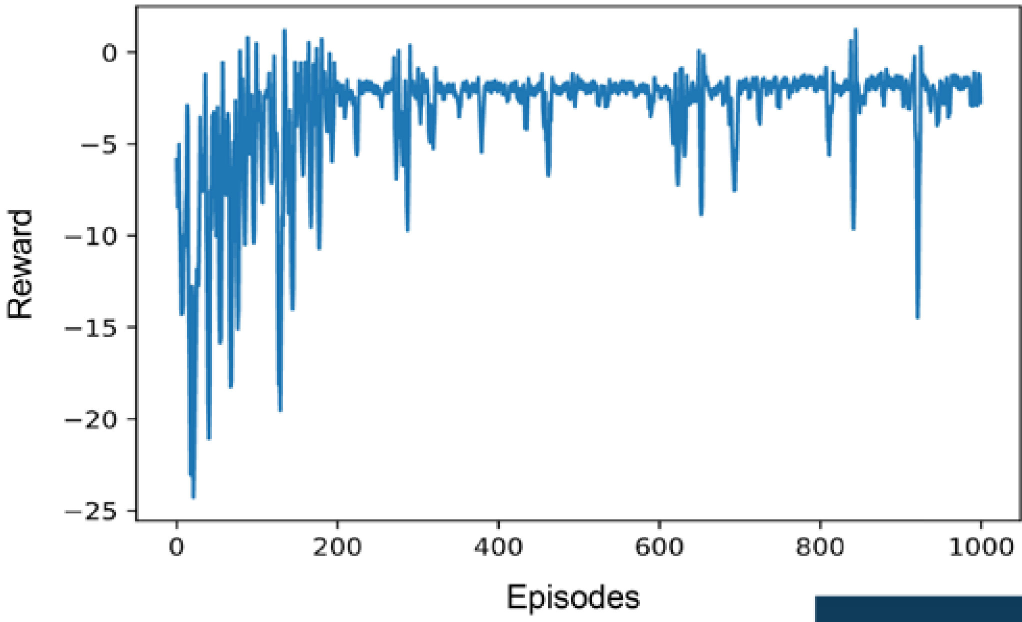


Figure 3: Evolvement of the reward signal received by one agent per episode over the entire training period of 1,000 episodes.

multi-robot systems requires extensive manual efforts resulting in long-lasting ramp-up and downtime phases. In addition, the hierarchical and modular approach proves to be particularly efficient when dealing with further use cases: By reusing existing learning environments, which may need to be slightly adapted to new tasks, development times progressively decrease. Accordingly, the efforts are mainly reduced to deriving the higher-level control structure from the structure of the manipulation task, monitoring the training processes and validating the final multi-agent solution.

Conclusion

The presented approach shows that multi-agent-systems based on deep reinforcement learning can enable efficient and full automated trajectory planning for dual-robot systems. Operation times can be decreased by 46 % in comparison to a single robot for the considered pick-and-place task. Future work will focus on a more complex dual mode manipulation task by handling a heavy component that exceeds the maximum payload of a single robot.

Lessons learned

- Simulations can be used for autonomous AI-based trajectory planning for dual robot systems
- While setting up the system architecture and especially the communication between simulation and learning environment, keep complexities low at first and focus on a working infrastructure
- Once the infrastructure functions, perform short adapt-train-evaluate cycles on the learning environments to obtain the desired agent skills
- Even if trajectory planning is conducted autonomously, it will require an unneglectable amount of computational time

Authors:

Christoph Nicksch

Research Fellow
Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen

Lars Leyendecker

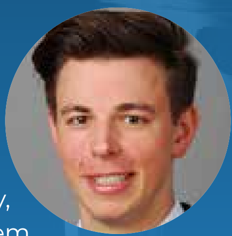
Research Fellow
Fraunhofer Institute for Production Technology IPT

Zhujuan Cal

Senior engineer
State Key Laboratory of Intelligent Manufacturing System Technology, Beijing Institute of Electronic System Engineering

Guocai Ma

Engineer
State Key Laboratory of Intelligent Manufacturing System Technology, Beijing Institute of Electronic System Engineering



Tobias Claus Brandstätter

Research Fellow
Fraunhofer Institute for Production Technology IPT

Fei Li

Senior Engineer
State Key Laboratory of Intelligent Manufacturing System Technology, Beijing Institute of Electronic System Engineering

Jonathan Krauß

Head of Department
Production Quality
Fraunhofer Institute for Production Technology IPT

Zhihong Cao

Engineer
State Key Laboratory of Intelligent Manufacturing System Technology, Beijing Institute of Electronic System Engineering

Robert H. Schmitt

Director
Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen and Fraunhofer Institute for Production Technology IPT

AI FUELS CUSTOMER GROWTH IN THE MANUFACTURING SECTOR

Empowering growth in the manufacturing sector with the next generation of customer insights.

Artificial intelligence (AI) is a game changer in the manufacturing sector. As the main driver of what many experts are calling the fourth industrial revolution, or Industry 4.0, AI is redefining everything from operations on the factory floor to back-office routines like sales and marketing.

AI itself is the product of one of the most pervasive technological trends of all – the exponential growth of digital data. Today's manufacturers routinely collect vast amounts of data from an ever-increasing range of sources, including customer touchpoints and connected devices on the factory floor. The challenge lies in making sense of this so-called Big Data in a way that is economical, scalable, and applicable in each unique manufacturing environment.

The rise of customer analytics for growth

Recent years have seen increasingly sophisticated algorithms draw AI out of simple support roles to become critical growth drivers in many organisations. Deep learning, active learning, and natural language processing (NLP) are just some of the exciting developments poised to change our relationship with machines. Today, AI is also changing the way businesses interact with their customers.

A recent study by the MIT Technology Review found that a third of sales and marketing teams are already using AI for customer growth. Moreover, it is expected that this figure will almost double in the next two years. After all, AI is already well established in other areas, including customer service and IT management. Indeed, the potential to drive growth by adding value to every mission-critical operation is enormous. This includes operations which are not directly connected to customer growth as well, such as production efficiency, financial operations, and risk-management.

Here are the three main areas where AI shows great promise in accelerating customer growth:

1 Sales

While manufacturing plant floors have been investing heavily into automation and optimisation technologies for years, revenue has largely remained stagnant. There are two key functions which are well-positioned for process improvement – sales and pricing.

Sales teams bear the responsibility to grow their customer base while retaining existing ones. Yet despite a reduction in labour costs due to transformational technologies on the shop floor, many sales teams are stuck with antiquated processes and solutions that lead to excessive customer churn. This is because they often lack the insights needed to better understand their customers.

AI can help sales managers prospect more effectively, reduce customer churn, and automate many onboarding processes. Relying on human analysis alone for pinpointing, for example, when customers are at risk of defecting to a competitor, simply isn't feasible for an organisation with thousands or tens of thousands of clients.

Machine learning can draw upon past successes and failures to determine things like which customers make the best fit for a given product or service and which ones are most prepared to purchase additional products. Empowered by AI-driven insights, sales teams can discover hidden revenue opportunities at practically any scale. They can optimise pricing, spend time prospecting for the right clients, and know who to communicate with and how, when, and why.

Marketing

No one expects a marketing department to work around the clock, but that doesn't mean their operations should be restricted to a nine-to-five routine. In fact, AI-powered systems already work around the clock behind the scenes of thousands of popular consumer and business products and services. These solutions are extremely diverse too – ranging from AI-powered discoverability engines that help customers choose the best products and services for them, to displaying ads at just the right time and place.

Applying customer analytics for growth across sales and marketing departments helps them achieve alignment and optimise efficiencies across the board. For example, labour-intensive things like direct-mail marketing and social media can be automated to free up time for teams to focus on activities which require a human touch.

AI can help continuously optimise the overall customer journey and customer experience. At the top of the sales funnel, it enables better lead targeting before moving down the funnel into a smoother and more consistent marketing process across every touchpoint. Marketers can use their automation tools to ensure a timely and well-placed execution of their campaigns across multiple buying stages. All the while, automated analytics and reporting yields a steady supply of insights which can then be applied to improve and optimise the process.

AI takes the process a step further by automatically tailoring customer experiences according to certain variables, such as past-purchase history and client personas. This can be done with enormous speed and high precision, making it possible for marketing teams to carry out their operations at a scale that simply wasn't possible before.

3 Customer service

With customers now having unprecedented power to shape the reputation of any organisation they do business with, it's safe to say that customer service is the new marketing. In a sector frequently involving huge transactions and high-commitment contracts, manufacturing should also view customer service as a critical growth driver. Thus, it stands to reason their operations should be deeply intertwined with sales and marketing.

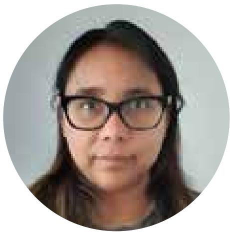
Yet automated customer service still gets a bad reputation. Frequent complaints include chat bots which fail to provide the right answers and automated support lines which continuously shift callers between departments. However, AI is steadily closing the gap between automated and human-powered customer support.

Innovative manufacturers are already looking into how they can use AI to improve customer service. Key areas of interest include predictive maintenance, and the ability to identify and resolve known issues with automated troubleshooting steps. After all, most customers would rather help themselves, provided they can find reliable solutions to their problems quickly, than pick up the phone or send an email.

AI can run self-diagnoses for predictive maintenance, which should substantially reduce the number of support tickets opened. This, in turn, will increase customer satisfaction – a direct driver of growth. Similarly, using AI to analyse vast amounts of customer feedback across the multitude of platforms ranging from support forums and knowledgebases to third-party review sites, can yield insights into more pervasive issues. Support teams can then escalate these recurring issues to resolve them in less time and identify which issues need a human touch.

Final words

Manufacturers face increasing pressure from regulatory bodies, environmental initiatives, and economic challenges associated with sudden, and often unpredictable, shifts in demand. Thus, the cost of not investing in AI for optimising mission-critical operations, is substantial, and it's only likely to get higher. The good news is that most plants already have huge amounts of potentially valuable data at their disposal. The next step is to implement a way to transform that data into insights that can drive growth.



Author:

Azlina Azman

Head of Communications & Digital Engagement
Fraunhofer Project Center
at the University of Twente

VR TRAINING FOR EFFICIENCY & IMPROVED RESULTS

Author:

Marjo Nieuwenhuijse

Founder
Serious VR / VR Training Academy

Companies worldwide dedicate large resources on training their employees, personnel or staff members. There is no doubt about the value of these trainings, especially in the industrial sector. However, what if costs can be cut down without sacrificing quality? This is where virtual reality comes into play.

By training in VR, companies can train their employees without the limitations associated with physical training. Moreover, the necessary time and costs can be cut down. Training can take place anytime and anywhere, while also increasing safety. VR Training Academy (VRTA), an initiative from Serious VR, aims to make these training applications accessible to companies of all sizes.

A shared vision

Founders Ton Kuper and Marjo Nieuwenhuijse have been working together on these practical VR trainings for a number of years. Marjo drew from her work experience to devise a plan. “As a company advisor I noticed a need for training methods without the usual downsides. Often the productions needed to be stopped during the training, costing money and time.” Ton and Marjo found each other with a shared vision about this market opportunity: this is where VR can be deployed with great value. VR training is not only more cost effective, it grants companies with flexibility not possible before. “Training no longer has to take place on the factory floor, for example. Companies can train their employees with the same content anywhere around the world.”

With VRTA Ton and Marjo have built a platform with an ever growing selection of widely applicable training applications. “Our NEN3140 training is a good example of this. The training is based on a widely adopted standard. This means many companies can use the training, as it is not built specifically for one client,” Marjo remarks. VRTA offers not only the training application itself: an extensive dashboard platform is part of the package. The dashboard offers detailed information about the performance of the users of the training. We call this our performance analytics. Learning from mistakes is only possible if insight into these mistakes is possible. That is exactly what the dashboard offers. Users can view their mistakes and try to improve them in the next training session. Company trainers can use these dashboards to gain insights into the strengths and weaknesses of any given employee that has participated in any given VR training. “The platform is now live and ready, but it is also forever evolving”, Ton adds. “Our team of developers and educational experts are continuously working to improve the platform based on the needs of our clients and partners.”

Intelligence, emotions and now skills

The VRTA platform and its performance analytics are not just numbers. A variety of performance indicators were selected based on academic research. These indicators were then matched with the trainings to make performance measurable. This part is key, Marjo explains. “While the definition of a professional is clear, companies often struggle to determine whether someone is indeed a professional. Everything that is measurable can still be subjectively graded.” Therefore, VRTA already has a new quotient in development: the Skills Quotient. “In our society we already adopted the IQ and EQ factors, now we also want to measure skills and performance.” This completes the package: not only can a VR training cut down on resources and time, the training also produces a measurable statistic.

> *We really believe that experiencing virtual reality is always more valuable than telling you about it. That is why you are invited to try out our demos at our office in Enschede or via an online demonstration.*

Marjo Nieuwenhuijse
Founder
Serious VR / VR Training Academy

Value in assessment

VRTA training applications generally consist of three parts: instruction, scenario(s) and an assessment. During the instruction, the user is guided through every step. The instruction is also included to ease the user into using the application. Not everybody is used to virtual reality. For example, a valve may be highlighted to indicate an action is to be taken here. Sometimes a transparent copy of an object is used. This 'ghost' shows the user where a fuse needs to be placed for instance. In an instruction, no mistakes can be made.

The scenarios are different. The procedure is the same, but now the user has to reproduce the steps from the instruction on their own. This is where the user has to rely on their own knowledge and memory. They can make mistakes, correct themselves and learn in an interactive environment. Got stuck? With a press of the button the help systems are re-enabled. The challenge in the scenario can be the same as in the instruction, but it is also possible to create variations. In these variations, the user may be confronted with a different situation or a distraction. "Companies find the scenarios particularly valuable. In VR we can confront employees with situations and distractions that are simply not feasible in a physical training", Marjo explains. "And even if they are possible, it would not be realistic cost wise."

Finally, the assessment is used to evaluate the employee. The challenge is again the same as the scenario, but now all scoring and monitoring is active. The results for each user can be viewed in the VRTA dashboard. Marjo: "There is great value for companies here. Not only can companies train existing employees, but the assessment can also be used in a selection process with applicants. For example, invite ten applicants for an order picking job and have them do our order picking assessment. Those who pass move on to the next selection phase." Not only is this an efficient way of working, it has other benefits too. "Our application always evaluates objectively based on parameters set beforehand. It takes human emotional judgement out of the equation", Marjo adds.


VR
TRAINING
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What advantages can
VIRTUAL
REALITY
bring to your company?
INTERESTED?
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for more information and the latest offerings.

THE *'LAST MILE'* FOR *E-COMMERCE*

In recent years, the rise of e-commerce has strongly impacted supply chain management strategies, forcing companies to look for solutions that will make delivery systems more sustainable and efficient. The steady increase of Business to Consumer (B2C) e-commerce has intensified as a result of the COVID19 pandemic, heavily increasing the amount of home deliveries. In terms of energy and emissions, the environmental implications of B2C e-commerce are considered to be one of the most pressing challenges currently faced by retailers. Artificial Intelligence (AI) systems offer solutions for making delivery operations more efficient and hold the potential of reducing CO_2 emissions during 'last mile' deliveries.

The 'last mile'

The term 'the last mile' refers to the last part of the supply chain, from the last distribution centre to a consolidation point. This last stretch of delivery is very costly to organise and carry out, generally accounting for 13 – 75 percent of total delivery costs. The exact amount varies depending on case-specific factors such as consumer service levels, type of delivery, geographical area, type of urban development, market penetration, warehouse location, and other environmental factors. Transportation accounts for the largest share of emissions in the entire supply chain, and the small scale of home deliveries have the highest environmental impact in terms of CO_2 emissions. Failed deliveries and product returns imply extra costs and extra kilometres of vehicle emissions. For these reasons, 'the last mile' is considered to be the most expensive, inefficient, and polluting part of the supply chain.

This issue has only been heightened by the retail promise of short-term deliveries, namely next day or even same day deliveries. E-commerce consumer demand has pushed the market towards offering express deliveries in order to compete with in-store purchases. It offers the chance of reducing physical stock and fulfil demands directly from a warehouse, reducing in-store costs. Therefore, companies are being forced to find the most time-efficient delivery methods in short-term notice, resulting in decisions that might not entail the most environmentally friendly practices. An example of such decisions is the use of standardised box sizes that might be too big for the packaged product, decreasing transport space efficiency, resulting in a rising number of CO2 emissions per metric ton. Another example might entail the use of third-party delivery services that can guarantee delivery dates and times, while still using heavy transport to travel long distances for a single delivery. As a consequence, 'the last mile' delivery of a product ends up being 5 to 23 times more expensive than in-store purchases.

AI for a sustainable supply chain

By optimising routes for urban freight distribution, companies can save time, reduce distance travelled, optimise vehicle use, decrease waiting times, and minimise CO2 emissions. It is clear that optimal transportation planning and management are crucial in the environmental impact of the entire supply chain process. But these tasks cannot be performed by human staff with the efficiency, precision, and quick response times that the market currently demands. At the same time, it is relevant to have a complete understanding of the distribution network design and the environmental impact of choices within that network structure. This calls for highly precise real-time analysis of large sets of complex data that are carried out by AI, also called big data analytics.

In order to decrease the environmental impact of 'last mile' deliveries, AI analyses historical trends, predicts patterns and determines

which specific order should be processed and how it will be delivered. It can also help direct supply and even use that data to overcome fluctuations on demand during holiday periods. AI holds the potential to perform all these tasks while accounting for environmental factors such as use of energy efficient transportation, weather changes, and other geographical characteristics that can have an influence on delivery times and environmental impact.

The next step for e-commerce

AI offers solutions that can help tackling climate change by reducing CO2 emissions while maintaining a certain degree of trust between stakeholders. Streamlining delivery orders can save costs while optimising the delivery process, efficient control of such interactions is very important within large-scale network systems such as supply chains. AI technologies can also carry out business layer functions such as courier management, merchant management, scheduling detection and distribution monitoring, even adjusting distribution networks in real time. By using AI for supply chain management, companies can not only achieve their sustainability goals but increase their value and competitiveness with minimal human input.

Large companies such as Amazon and Alibaba are already further implementing AI in their supply chain by incorporating electric and/or autonomous vehicles for 'last mile' deliveries. They are able to make supply chains even more efficient while reducing the environmental impact. Drones are also being implemented for light deliveries in highly urbanised areas with highly optimised routes and virtually zero emissions. These e-commerce giants setting the high customer expectations in terms of delivery speed, service quality, and sustainability. The market trend for fast, cost-effective and safe deliveries is only expected to grow, and AI offers the tools to fulfil market demands while offering sustainable solutions.

Yet, the question remains: how far are we willing to let AI help us achieve our sustainability goals?

AMCNU

BOOSTING INDUSTRIAL GROWTH WITH EMERGING TECHNOLOGIES

Together with regional government and partners, the Fraunhofer Project Center (FPC) has developed the Advanced Manufacturing Program (AMP) to establish a transitional framework towards Manufacturing 4.0 and empowering manufacturing industries in the Eastern part of the Netherlands.

The Advanced Manufacturing Program (AMP) provides subsidies through the RegioDeal supported by the Province of Overijssel and the Dutch state. It aims to encourage rapid development of Twente and other regions in the East Netherlands by forming an Advanced Manufacturing hub with an outward looking European image. With this the AMP greatly enhances the region's reputation and business climate.

Within the AMP, the Fraunhofer Project Center at the University of Twente develops innovation projects around manufacturing technology themes. Every AMP project is built around solid industrial collaboration, empowering companies with relevant knowledge and new technological and industrial methodologies, Through the hub, these can be shared with other high-tech manufacturing industries in the region.

Member companies' of the AMP can solve their specific technology problems and answer their market-oriented questions. This is achieved by developing and creating demonstrators that offer participating companies direct technological insight. FPC then utilises workshops and master classes to further disseminate this newly acquired knowledge.

> **The Advanced Manufacturing Program (AMP) is a funding program that helps us support you in your transformation to manufacturing 4.0. IT is made possible through the RegioDeal supported by the Province of Overijssel and the Dutch state.**

Rijksoverheid provincie Overijssel regio Twente Twente

ENERGY AND RESOURCE MANAGEMENT

Current trends from environmental, social and economic perspective force manufacturing companies to improve their energy and resource management. Especially the attention to environmental aspects like global warming or resource depletion is accelerating and different drivers are exerting pressure on companies. Besides more and more political attention and rising public awareness, drivers like increasing energy and raw material prices, potential lack of critical resources, necessary investments for environmental regulations and introduction of CO2 certificates all directly connect environmental driven issues to business objectives of a company.

Manufacturing processes have a significant impact on the environment. Energy is used to process raw materials and transform them into products and wanted or unwanted by-products. While one part of the resources is used for creating value and embodied into the form and composition of products, another part is wasted in terms of material losses, heat and emissions. From mining (extractive industry) to the processing of materials (material industry), through manufacturing of discrete products and finally the waste industry: altogether significant quantities of energy are needed which lead to respective energy related emissions. This has resulted in the manufacturing industry being one of the largest energy consumers and greenhouse gas (GHG) emitters in the world. In Europe, the manufacturing sector is responsible for about 26% of the primary energy use and 20% of the annual GHG emissions, of which the material industry plays a leading role [1]. Designing and improving manufacturing systems while advantageously integrating economic, ecological and social goals have become an essential objective in the manufacturing industry.

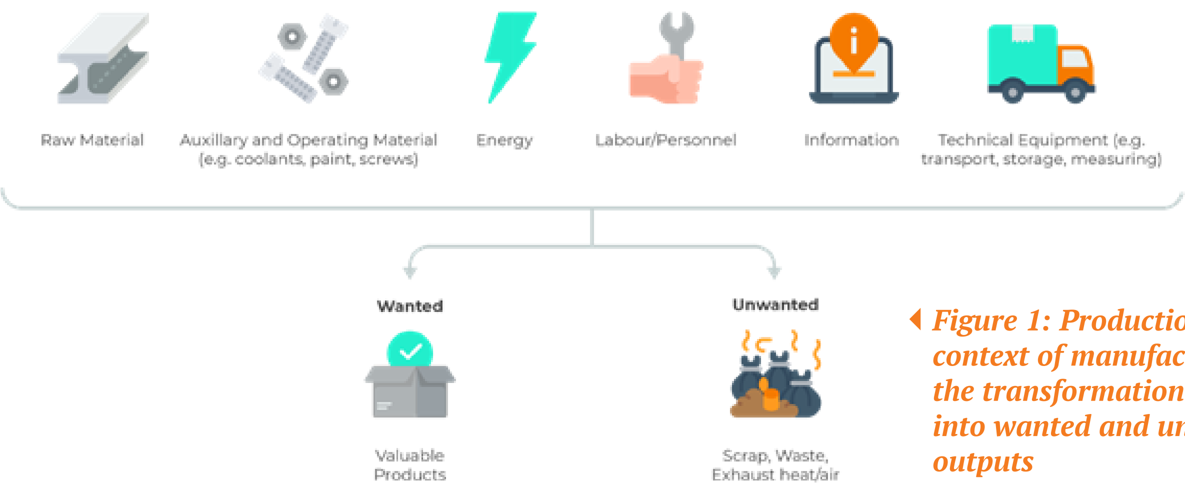


Figure 1: Production in context of manufacturing is the transformation of inputs into wanted and unwanted outputs

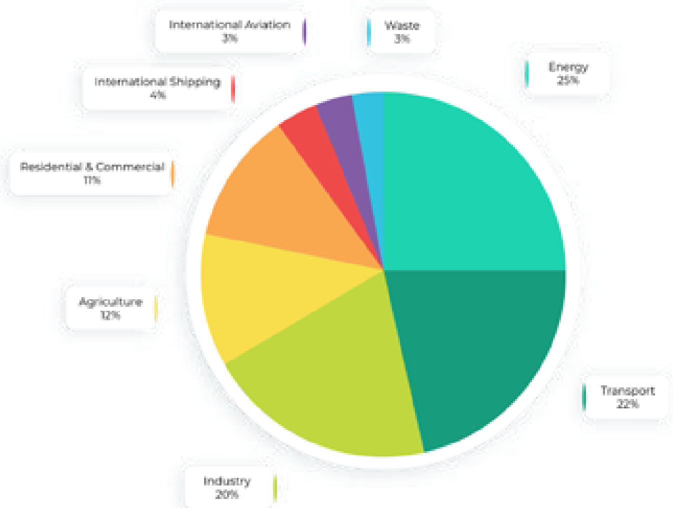


Figure 2: Annual greenhouse gas emissions in the EU 2019 (European Environment Agency)

Reference framework

Before we can identify potential fields of actions, we have to consider the reference framework of manufacturing. Industrial activities typically take place within dedicated factories. Factories consist of three subsystems: production equipment, technical building services (for internal energy conversion, providing production conditions like temperature, or humidity) and building shell. Those subsystems are connected through energy, material and information flows. Material flows consist of raw and auxiliary materials, waste streams and (semi-) finished products. In terms of energy, different energy carriers (for example electricity, gas, and compressed air) are externally acquired or internally generated/ converted. The information flows allow monitoring and therewith planning and control of operations.

A major change deriver in these flows is the digitalisation of manufacturing industries. Innovative technologies for sensoring, communication, data processing, and visualisation can improve planning and operation of manufacturing. Besides targeting customised production and lowering throughput times, also energy and resources efficiency can be addressed [2,3].

Within Industry 4.0 four different maturity levels can be distinguished, being: visualisation ('What is happening?'), transparency ('Why is this happening?'), prediction ('What will happen?'), and automated adaption ('How to respond (autonomously)?') [4]. Higher maturity levels are associated with increasing benefits but also more complexity and efforts. Bringing together those functionalities with the derived fields of action and different factory levels results in the reference framework shown in Figure 3. Within the boxes also the use scenario (planning and operation) is indicated. This framework gives an overview of all combinations and allows a systematic structuring and assessment of digital solutions.

Potential Field of Action

Based on the above mentioned interrelated energy and material flows, three potential fields of action towards more environmentally sustainable manufacturing can be identified (based on [5]):

Digital methods and tools can play an important role towards more energy efficient solutions, both in the planning of production and the support in operation. The former can see major improvements from the selection of the most efficient technologies. Machine learning can be used to systematically identify best practices among production machines or production areas within a company.

[1] European Environment Agency, Annual report 2021
[2] Kagermann, H., Helbig, J., Hellinger, A., Wahlster, W. (2013). 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, 2013.
[3] Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., Kim, B.H., Do Noh, S. (2016). Smart manufacturing: Past research, present findings, and future directions. In: International Journal of Precision Engineering and Manufacturing-Green Technology, 3(1), p. 111-128.
[4] Schuh, G., Anderl, R., Dumitrescu, R., Krüger, A., Ten Hompel, M. (2020). Industrie 4.0 maturity index: Managing the digital transformation of companies (Update 2020), acatech study.

More relevant use cases can be found when it comes to support in operation. Based on up to real-time data, parameters of processes (such as temperature setting, or machine speeds) can be adapted.

The substitution to renewable energy sources is a powerful strategy that can significantly reduce the energy related GHG emissions. Besides the production of own renewable energy, the concept of energy flexibility has gained interest by industry. Within that, companies dynamically change their energy demand behaviour depending on the market price and/or the availability of renewable energy. From material perspective, modelling approaches could be used in planning and operation to predict the impact of substitution. For example product related materials but also auxiliary materials, like cutting or cooling fluids.

As for material efficiency, improvement potentials can be found in avoiding waste materials or quality rejects as well as fostering recycling concepts. In the planning phase, digital methods can support to derive material efficient designs. While for operation, digital methods can help to derive root causes of material inefficiencies and low quality rates.

Call to action

As indicated, there are manifold digital solutions that can potentially support to significantly improve the environmental impact of manufacturing. Driven by various actors, manufacturing processes must minimise negative environmental impacts. Balancing energy efficiency, material efficiency and substitution is challenging; possible approached include visualisation, transparency on root causes, prediction and ultimately autonomous adaption. A digital environment will allow companies to develop a scalable decision-making support tool to identify and continuously improve measures for a target oriented energy and resource management. It opens up new manufacturing possibilities in monitoring and improving their energy and resource demands by creating recommended scenarios that indicate how to improve efficiency, transparency, utilisation of energy and resources, and, at the same time, is compatible with the current digital infrastructure of the company.

If you wish to know more about how Energy and Resource Management can be useful for your manufacturing setup? Please contact Fraunhofer Project Center at the University of Twente and we will explore this together.

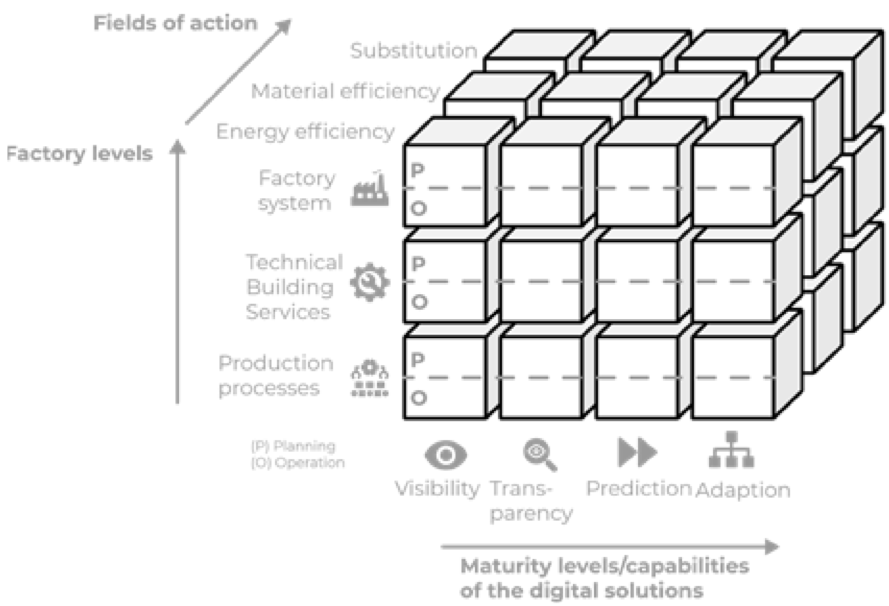


Figure 3: Reference framework for digital solutions towards sustainable manufacturing [5]

[5] Thiede, S. (2021). Digital technologies, methods and tools towards sustainable manufacturing: does Industry 4.0 support to reach environmental targets?.

H@cking for the future

Authors:

Irfan Pottachola

MSc Construction Management and Engineering
Student Assistant
Fraunhofer Project Center
Expertise Student Team

Karl Lossie

Community Manager
ICNAP
Fraunhofer Institute for
Production Technology IPT

The core of Fraunhofer Project Center Expertise Student Team (FEST) is innovation and personal motivation to learn, grow and develop. But where do ideas come from? One important aspect is indeed enthusiastic individuals. How do we gather and work together with such enthusiastic individuals? One interesting and unconventional way for this is a hackathon!

Traditionally, a hackathon is a physical event where programmers and software developers come together to find solution for a problem in a short timeframe. What this event is can be easily explained using the two words which came together to make the word hackathon: ‘hack’ and ‘marathon’. ‘Hack’ represents the creative problem-solving aspect of the event; after all, the main goal of the event is to solve a problem. Marathon, on the other hand, represents the restricted time frame of the event, which requires the participants to work in a continuous stretch until the solution is found, sometimes even through sleepless nights!

Together with the ICNAP community of Fraunhofer IPT, the Fraunhofer Project Center organised and hosted the ‘hacking for future’ online hackathon on April 22-24, 2021. The goal of the event was to bring together enthusiastic students from Germany and the Netherlands to solve cases of ICNAP’s partner companies, thus sparking ideas and innovation within the community. With the pandemic situation, organising a physical hackathon was neither possible nor responsible. Thus, the decision was made to make the event completely virtual. 40 students from Germany and the Netherlands, split into 11 diverse teams worked virtually on one of the three challenges provided by the partner companies of ICNAP over 35 hours. The amazing challenges and the crisp virtual environment created by us resulted in a fun and insightful weekend for the students and the ICNAP community.

What were the challenges?

The first challenge of the hackathon was Machine Learning (ML) model interpretation from IconPro. IconPro uses ML models for preventive maintenance. However, since ML models are often considered as a black box, the models should be fair and reliable for them to be used in an industrial setting. Model fairness and interpretability are critical for production engineers to explain their models and to understand the accuracy of their findings. There lies the goal of this challenge. The objective put forward was to interpret a trained ML-model using CXPlain and SHAP library and compare results from both libraries qualitatively. Through this, IconPro could get insights into which model interpretation library they should use in their processes to understand and explain their ML-models most accurately.

The second challenge by Leadec was related to Dynamic anomaly detection of vibration data. The objective of this task was to develop an auto-threshold configuration algorithm for vibration sensors. Vibration sensors are frequently used in smart factory applications and the standard threshold for alarms are usually configured using ISO standards. This however does not reflect real life sensor applications and installations because of various factors. The task therefore was to develop, verify and deploy an algorithm, that can individually generate thresholds through learning data from the first vibrations after the installation of the machine, and is able to continuously retrain itself with the incoming data.

The third challenge jointly from Oculavis and Philips and was about Automatic 3D model creation for industrial Augmented Reality (AR)/ Mixed Reality (MR) applications. With the increasing spread and utilisation of AR and MR applications in manufacturing, creation of 3D models which accurately depict the characteristics of real-life objects can have numerous advantages. If, for instance, assembly instructions for an engine are to be provided

to assembly workers, a precise model of the engine might be useful to visualise assembly steps with a high accuracy. Automation of this process would add significant value to otherwise time-consuming task of designing a 3D model. Thus, the objective of this task was to find a way to automate the creation of a 3D model of a real reference object.

The event in a virtual world

Now the challenge for us as organisers was to create a virtual environment which can facilitate creative problem solving during the hackathon. The physical venue of the hackathon plays a key role in stimulating the flow of ideas. It was necessary to provide an environment closer to that in the virtual world to help the participants survive the marathon. After lots of deliberation and brainstorming, we created a flawless virtual environment which provided the participants with everything they needed to take them through the fast-paced weekend with sleepless night(s). A communication platform was set up for teams to work together and to find all the information needed for their respective challenge in one place. Aside of that, a 'virtual space' was set up which allowed participants to move around, meet new people and network with the ICNAP community. The exciting part of a hackathon is also meeting new people from different backgrounds. To provide this, we opted for a platform that allowed people to virtually 'wander' in an open space, bump into each other during their wandering and start one on one or group conversations. To make it a bit more realistic, we created rooms in the virtual space, which corresponded to a 'coffee room' or 'dinner table' of a physical hackathon, so that participants can run into each other when they are taking a coffee or dinner break, just as in real life. We also hosted virtual workshops in which experts from the industry provided tips and tricks for the participants to hack their challenges.

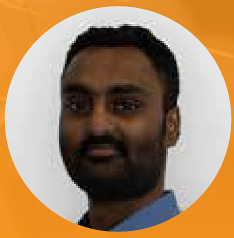
The result was an amazing weekend and a happy bunch of participants. Three or four teams worked on each challenge, most of them pulling out not one but two sleepless nights and delivered amazing results and ideas for the companies. "How the event was set-up, especially this virtual space, really helped us to work from our home comfortably", said Djamila Barbara Zimmermann, which was the general feeling across the camp. The students had an amazing experience, which was very evident in the impressive solutions for each challenge; choosing winners was a difficult task for the jury. The solutions perhaps even caught the jury by surprise, which resulted in them declaring shared winners for two of the three tasks. And of course, we never allow hard works to go unrewarded. The participants were rewarded with amazing vouchers for their excellent efforts over the weekend; happy students, overjoyed hosts and delighted ICNAP members!

Such remarkable ideas and solutions which came to light from the extraordinarily agile brains of young budding professionals through a diverse multidisciplinary collaboration can indeed become the spark we need to light the future of advanced manufacturing.

◀ *Event advertising*

MANUFACTURING INDUSTRY

AI in the manufacuring industry



Author:

Hari Subramani Palanisamy

Research Engineer
Fraunhofer Project Center
at the University of Twente

Manufacturing industries are transforming in the past few decades to satisfy the global expansion of product demands. Such transformations are becoming more relevant and essential to meet the flexible expectations of the customers. To enable a sustainable transformation, each process in the entire value chain has to be adapted based on the product needs, which can bring upon positive impact on their competitive global market. Due to proper utilisation of natural resources and massive labour force, an era of industrial revolutions has been inaugurated, to meet large production volumes. However, over a period, successive technological advancements enabled us to integrate electricity and electronic components to speed up the manufacturing processes along with much high precision. Now, it is time for a giant leap in recognising the fourth industrial revolution which is termed as "Industry 4.0" with much more sophisticated technologies. Industry 4.0 technology can be systematically incorporated into the industrial process chain to reap evolutionary digital transformation.

Often, the term "Industry 4.0" is interchangeably used with "Smart manufacturing" and "Industrial Internet of Things (IIoT)". In bigger picture, all three concepts generally hold the same main functions, which include connectivity, data analytics, intelligent decision making, flexibility and adaptability. However, the differentiations can be derived based on their application and use cases. Nevertheless, Industry 4.0 focuses on establishing digital transformations which can enable manufacturing industries to achieve a connected ecosystem along with the smart decision making capabilities for their process chain. In essence, Industry 4.0 offers an efficient approach in interlinking hardware systems with digitalisation, thereby allowing better connectivity and real-time data analytics.

The power of AI

Digitalisation can be incorporated in each stage of the process chain which include but not limited to product design, production planning, manufacturing, and supply chain management. Integrating digitalisation can enable industries of all sizes to deploy existing and future technologies for more flexible, optimised, energy efficient, and automated solutions. This allows industries to properly utilise the full potential of Industry 4.0 and prepare for the next phase of their digital transformation journey.

As the real-time complex data analytics are becoming an integral part of the Internet of Things (IoT), it is inevitable to harness the power of Artificial Intelligence (AI) in understanding the sensor data, and to make smart decisions with minimal human intervention. AI integrated with IoT can offer local devices an ability to process time-sensitive data efficiently in terms of energy, rather than demanding centralised cloud computing technology.

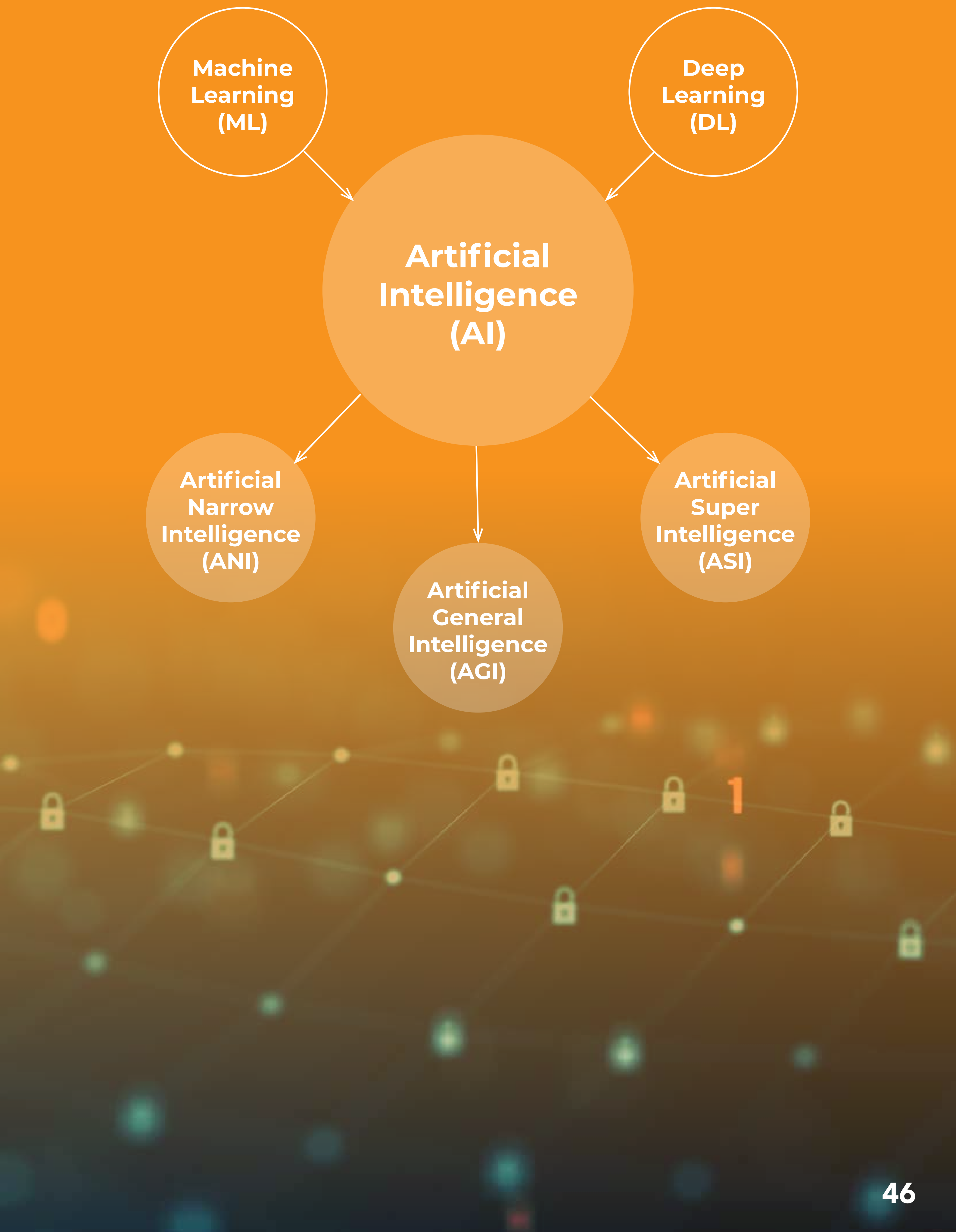
It is obvious that AI is engulfing us in this Industry 4.0 era. We are experiencing several articles with overwhelming information and opinions on AI. Because of the constant flow of information on AI, it is becoming increasingly difficult to pinpoint what exactly AI is all about.

AI typically covers concepts involving Machine Learning (ML) and Deep Learning (DL). It is very important to understand the difference between these terms and its associated applications. Proper understanding of these concepts can guide us in choosing an efficient approach suitable for a specific industrial problem.

ANI, AGI and ASI

AI can be termed in such a way that any intelligent system can identify efficient methods to solve a problem. This can be done by proper utilisation of sensor data, learning from experiences, and also by adjusting to new inputs. AI can be employed in applications requiring human-like intelligence in solving a problem and deliver solutions with minimal human interventions. Considering the application domain, hardware infrastructure and ability to perform a task, AI can be broadly classified as Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI).

ANI was carefully designed with a capacity to perform actions on a single specific task. Actions are performed by utilising necessary information from its pre-defined set of knowledge representations. Having proper knowledge representation, ANI has successfully demonstrated in outperforming human achievements for a given specific task. For example, beating humans in the game of chess, image classification, and virtual assistants like Siri, Alexa, etc. ANI also has a great potential in relieving humans from mundane tasks in industries. On the other hand, AGI refers to technology which can exhibit human-like intelligence and ASI refers to technology which can surpass human intelligence. Both AGI and ASI are still under scientific explorations and needs further advancements to realise their presence as a functional applications.


Machine Learning (ML)
Deep Learning (DL)
Artificial Intelligence (AI)
Artificial Narrow Intelligence (ANI)
Artificial General Intelligence (AGI)
Artificial Super Intelligence (ASI)
1

Based on the functions of ANI, it has a greater potential to be incorporated as an applicable solution for wide spectrum of industrial problems. ML being one among the beneficial applications of AI, has a capacity to identify patterns using statistical methods, which allows software systems to learn automatically from experiences without any preprograming to accomplish a specific task. However, ML typically requires human interventions to determine the hierarchy of features for a given set of structured inputs to make predictions. Based on the choice of ML algorithm, they may require a small to large set of data to extract relevant information about the process.

In contrast to ML, DL automates much of the feature extraction process thereby eliminating most of the human interventions. It also enables us to process large data coming from complex industrial applications. Deep learning concept is an evolved form of Artificial Neural Networks (ANN), which is inspired from neurons in the biological brain for processing information. The term "Deep" referred in DL technology is due to the stacking up of multi-layered neural network that consist of a large number of parameters. Input data (numbers) is processed through several layers of neurons called neural networks to predict and classify information. Based on the availability of labelled data, ML and DL technologies can be classified either as supervised, unsupervised, or reinforcement learning.

AI applications in manufacturing

Manufacturing industry whose journey is currently focused towards digital transformations can efficiently harness the power of AI to transform their process chain and increase productivity. One among the key requirements is to provide advanced data analytics, which can be possible with ML and DL technologies. Another application of AI in manufacturing industry is to enable smart maintenance, where ML algorithms can provide predictive maintenance analyses to determine the status of products and machinery. Such early detection can eliminate downtime and the Remaining Useful Life (RUL) of equipment can be efficiently extended.

In addition to smart maintenance, the quality of deliverable products can be drastically improved by identifying the potential defects beforehand which can tarnish business if unnoticed. For quality inspection processes, "Machine vision", sometimes referred to as "Computer vision" integrated with deep learning technology can take the responsibility in classification and detection of defects. Vision guided data analytics can be integrated to a manufacturing process line where for example surface quality of a product is of utmost importance. Visual quality inspection is very helpful to manufacturers during the processing of goods which can relieve them from long hours of manual inspection and at the same time to maintain quality standards with high precision.

Large scale manufacturing industries have established steps to successfully incorporate AI to their process chains and continue to push their boundaries in improving productivity, product quality, and supply chain management. But when it comes to small scale industries, still the decisions are dicey to realise transformation in their manufacturing process, assisted by intelligent solutions. One brave step towards integrating AI can unleash the true potential of digital transformation in manufacturing industries of all sizes. Thanks to the power of AI, availability of resources, and competitive skills to make Industry 4.0 accessible to every industry.

> ***Large scale manufacturing industries have established steps to successfully incorporate AI to their process chains and continue to push their boundaries in improving productivity, product quality, and supply chain management.***

AI AND THE DIGITAL TWIN

(POWERFUL COMPANIONS)

Digital Twins bridge the gap between what is physical and virtual, with the growing emergence of the Internet of Things (IoT) enabled devices, can empower firms to realise value in completely new ways.

Digital Twins are a kind of advanced and living evolution of a traditional simulation, using real data from systems and providing an accurate and smart representation of processes, systems and equipment. They link these entities to connect people, processes, and equipment together in a cyber-physical environment. The entities that can be included in the makeup of Digital Twin design do not follow any strict set of rules, and are adaptable to any manufacturing environment that can be digitally enabled through smart sensors and IoT data connections. In a manufacturing environment, this living data-driven tool can be extremely powerful for manufacturers, especially when complimented by modern artificial intelligence (AI) technology.

Coupled with AI, a Digital Twin can offer a dramatic increase in capability and value offerings for any manufacturing firm. With a constant stream of data from an array of machines, equipment and process monitoring systems, the Digital Twin can recommend and drive actions and tasks that are needed at the operations level in the physical world. For example, engineering teams can enable the Digital Twin to simulate scenarios and so learn to problem solve on the fly. By using live data, the processing alternatives can be implemented to avoid bottlenecking and prolonged downtime, therefore maintaining manufacturing flow and output.

For daily and routine operations, the same technology provides value in instruction and guidance. Smart devices can provide operational staff access to interactive AI tutorials that are adaptable to the particular task at hand. These AI based tutorials can show an operator how to control or operate new equipment, or describe changes to work procedures, while the system simultaneously provides real-time logging and feedback.

For example, many manufacturing environments require the careful, controlled use of specific cleaning solutions and hand tools for routine cleaning of sensitive tools and equipment. AI technologies can enable live guidance with environmentally-based prompting, to better enable the manufacturing operative to follow (often) complex work instructions. With this kind of augmented reality system assistance, the operator can reduce re-training time in the event of process changes, while also helping to eliminate costly human errors. These types of applications are only just beginning to be realised in industry, with a blue ocean of application opportunity on the horizon.

A core business function - as described above, is not yet common-place across all manufacturing industry. Companies wishing to realise value from these technologies need to understand that AI is rapidly becoming a core tool in the manufacturing engineering toolbox. To harness the true power and value within a Digital Twin makes access to such AI processing technology a requirement, not an option. Traditional computer simulations struggle to support, with large simulations often taking hours to days. The lack of speed and processing power required to simulate, handle large data, and give outputs in real time, sees AI as a necessity for modern real time simulations.

Expect to see an increasing focus placed on AI and the digital twin in the future, as manufacturing industry begins to truly realise the competitive advantages, efficiency gains, and the unrealised values that these new technologies can deliver.

Author:

Rob Leen

Design and Process Engineer
Partington.cc Pty Ltd.

SHOP FLOOR IN CONTROL

Author:

Eric Klement

Director Sales
Smart Production Solutions

As the manufacturing industry shifts towards high technology becoming common place, many changes and transitions will have to be carefully managed. New processes, business models and best practices will have to be adapted and created to enable maximum utilisation and capability of new technology. Navigating this change requires strong thought leadership from our industry managers and support in digitisation across different levels of a business.

Supporting and enabling change in the rapidly evolving digital manufacturing world is something that Smart Production Solutions has been carefully developing to enable manufacturers to thrive in an evolving industry. Thought leadership relies on strong collaboration from both business leaders and industry technology experts in designing and managing change. It requires constant consultation and feedback from all stakeholders involved, to tailor a solution that is a bespoke fit for a business' unique needs and circumstances.

Prior to any groundwork being undertaken, solid thought leadership involves developing strong long-term strategies that will create a foundation for setting and achieving goals and objectives on an advanced manufacturing journey. Establishing such well-designed frameworks support and guide the implementation of what can be complex projects. From early-stage digitization through to providing the app-based tools and systems needed to a create smart and efficient information flow, Smart Production Solutions have proven how critical this collaborative and holistic approach is.

Smart Production Solutions supports manufacturers towards the upcoming world of Artificial Intelligence. To rely on Artificial Intelligence, data is necessary. Smart Production Solutions provides and gathers all kinds of necessary and crucial data created on the shopfloor. Smart Production Solutions guides it customers in close cooperation during this journey towards Smart Industry.

Like every journey starts with the first step, the first step for manufacturers would be the digitalising of the shop floor. Nowadays, many manufacturers have a shop floor that is controlled by a paper flow. A way of control that is time consuming and inefficient. Time consuming because of overwriting and inefficient because information is delayed and not accessible for statistics.

Smart Production Solutions helps its customers, with apps bundled in the Smart Production Suite, gaining control of the shop floor by digitising the shop floor. Control resulting in, on the long term:

- Increase of efficiency
- Shorter throughput times
- 100% digital processes

On the short term, almost immediately when implemented:

- No more overtyping of paperwork
- Realtime insight in performance shopfloor
- Actual hours automatically booked on workorders
- Direct signalising in case of breakdown or quality issues

The Smart Production Suite

The Smart Production Suite supports the creation of a paperless shop floor. The Smart Production Suite is a bundle of smart intuitive apps providing people on the shop floor with the right information at the right time. Work instructions, drawings, tutorials... all provided digitally with the latest actual revisions. Apps that will assist people on the shop floor with easy and fast registration of time, material usage and possible feedback. The apps are designed to improve efficiency on the shop floor and shorten lead-times.

Highlighting 2 apps of the Smart Production Suite:

StockControl

StockControl supports easy registration of warehouse movements, goods received and pick orders and will replace all kinds of (written) lists.

StockControl is fed with realtime information from ERP or JobControl. In ERP or JobControl the warehouse movements are triggered and will be presented, based on selection criteria (like supplier, date, location, employee etc.), to warehouse employees. Transactions are easily registered by “clicking” on for instance a tablet. ERP will be updated realtime, giving you full overview of material movements. All pick orders, warehouse transactions and goods received are listed and presented based on priorities ensuring that material shortage is no longer a problem.

- Goods received
- Issuing / picking materials
- Request of materials

JobControl

JobControl replaces job lists, planning lists, handwritten notes for hours registration, quality forms and material lists. With the assistance of JobControl, the shop floor will receive digital job lists, sequenced based on your own priorities. Jobs will be enriched with digital information like BOM, work instructions, manuals and drawings. Time spent and materials used will be recorded by simple “clicking” by the operators. All information will be sent back realtime to ERP, making sure that you have continuous insight in statuses of workorders and material movements.

- Realtime control of shop floor based on planning & scheduling
- Registration of man and machine hours
- Digital drawings
- Registration of scrap and deviations

App & running methodology

The Smart Production Solutions apps are intuitive; the implementation will be carried out quickly and efficiently. Compare it with apps on your mobile; easy to install and ready to be used right away. The same counts for the apps of Smart Production Solutions. A typical project requires 1 days effort of Smart Production Solutions and the shopfloor will be up and running within 1 month.

4 steps for app & running implementation method:

1. *Workshop*

The workshop is intended to introduce the apps to future users. During the workshop, together we will decide how the apps should be configured. With the emphasis on together: discussing as many situations on the work floor as possible on the one hand and ensuring that the apps are embedded in daily usage of your operators on the other.

2. *Configuration*

In the configuration phase, the app is configured as agreed during the workshop. Resulting in apps that are supporting the processes on the shop floor of your organisation.

3. *Installation*

During the installation, the specified locations of your organisation are processed in the URL's of the apps. These URL's are then installed on the devices you have suggested. Because the apps are completely Cloud based, all kinds of devices can be used; touchscreen TVs, laptops, IPads or just the current PCs that you already have.

4. *Go Live*

We believe in the "train the trainer" principle. The apps are equipped with management tools that allow you to manage the apps independently. By transferring the knowledge to designated employees, enriched with documentation, we ensure that the knowledge is and will be present within your organisation.

Testimonial:

The range of agricultural machinery is extensive, and the machines can be specifically adapted to the circumstances of the end user. The Evers machines can be ordered through our own dealer network, both in the Netherlands and abroad. The development, sales, production and after sales service take place from the location in Almelo. Last year we have improved the efficiency and output in our production. To improve production output and efficiency we use various techniques. These techniques are amongst others the use of analysis techniques and production support techniques. Therefore, we have to measure our production in SPS.

> ***"With the help of JobControl we are able to register automatically the actual hours spent. We have more insight in the performance of our resources and are able to make accurate cost price calculations. Furthermore, this production technique helps to shorten the time-to-market of new products."***

Evers Agro

MD Roelof Kleinjan

Evers has more than 60 years of experience in developing and producing agricultural machinery. These machines are used for soil cultivation, slurry injection and grassland maintenance by farmers all over the world.

Curious?

The apps are fully integrated with Infor, Exact and Ridder iQ. Join one of the monthly webinars. Follow us on:

Smart Production Solutions

Contact:

Eric Klement
eric.klement@smartproductionsolutions.nl

FROM RAW DATA TO SMART MANUFACTURING

Author:

Thorsten Strebel

Managing Director
AIMES

> ***The significance of big data analytics-powered Artificial Intelligence has grown in recent years and it has the ability to enhance supply chain performance.***

Manufacturing organisations are now able to easily accumulate large amounts of shopfloor and environmental data due to advances in data collection, communication technology, and use of standards. The challenge has shifted from collection of data to analysing and decision-making technologies. The actual value of this huge amount of data can only be revealed once it is processed and visualised in an appropriate way. Manufacturing Analytics (MA) can help understand and gain insights into the collected data and in turn help advance towards the vision of smart manufacturing. MA includes a large range of methods, functions, and applications to analyse data and derive information or even real knowledge. The more complex these analyses become, the more important innovative technologies like Artificial Intelligence (AI), Machine Learning or Deep Learning are.

AIMES

The significance of big data analytics-powered Artificial Intelligence has grown in recent years, and it has the ability to enhance supply chain performance. With the help of Artificial Intelligence, large amounts of data can be processed in real time, and advanced planning and scheduling can be done automatically. Ideally, the insights gained are used to derive predictions for the future. To respond to this, the companies PerfectPattern and MPDV founded AIMES. AIMES (Artificial Intelligence for Manufacturing Excellence Solutions) has the objective to develop and provide software components for Artificial Intelligence (AI) for the manufacturing sector. Furthermore, AIMES will offer services for AI-based solutions in the manufacturing environment.

“With AIMES, we are adding a pivotal component to our product portfolio. After all, AI-based solutions are an essential factor in the manufacturing IT of the future,” says Thorsten Strebel, CTO at MPDV and now also Managing Director of AIMES.

The combination of PerfectPattern’s solutions in the field of AI and MPDV’s product understanding for IT solutions for companies worldwide, creates new business and growth opportunities for both partners, for the launch of new products for manufacturing analytics, planning, scheduling, and Predictive Quality. Predictive Quality is an advanced Industrial Artificial Intelligence process that is able to reveal the hidden causes of production losses that are faced by manufacturers on a daily basis. Examples can be any loss caused by process inefficiencies, like quality, yield, waste, throughput, energy efficiency and emissions. Driven by algorithms and uniquely trained processes, automated instructions and alerts can be generated to inform about an imminent problem, which can be prevented before it happens.

“Subjects like Predictive Analytics, Artificial Intelligence and Machine Learning are cutting-edge. By working with PerfectPattern and our joint subsidiary AIMES, we are strengthening our position in these fields and opening up completely new opportunities for manufacturing companies on the way to the Smart Factory,” says Nathalie Kletti, CEO at MPDV.

About MPDV

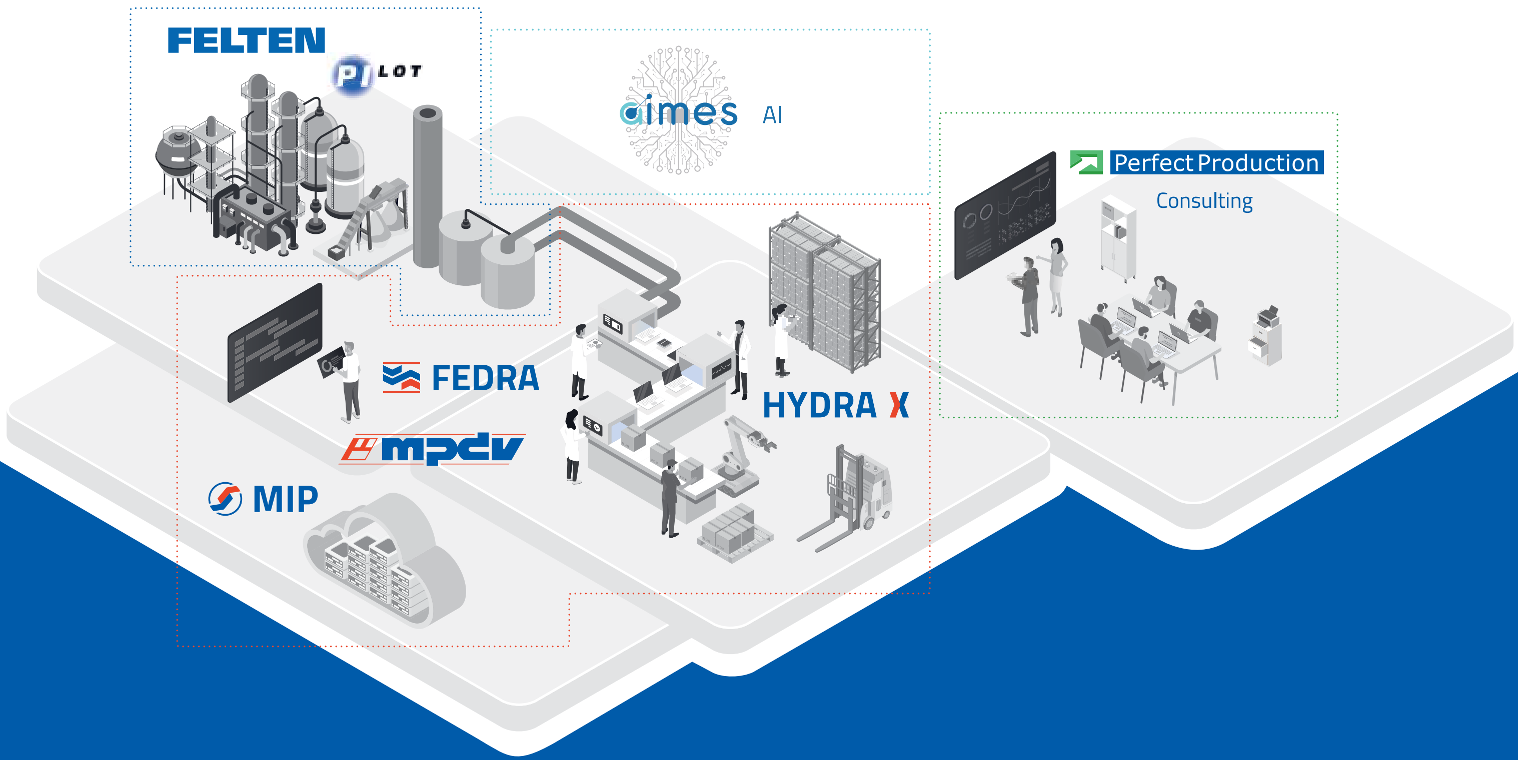
MPDV headquartered in Mosbach, Germany, is the market leader of IT solutions for the manufacturing sector. With more than 40 years of project experience in the manufacturing environment, MPDV has extensive expertise and supports companies of all sizes on their way to the Smart Factory. MPDV Products such as the Manufacturing Execution System (MES) HYDRA, the Advanced Planning and Scheduling System (APS) FEDRA or the Manufacturing Integration Platform (MIP) enable manufacturing companies to streamline their production processes and stay one step ahead of the competition. The systems can be deployed to record and evaluate manufacturing-related data along the entire value chain in real time. If the production process is delayed, employees can immediately detect the problem and take proactive measures. More than 900,000 people in over 1,400 manufacturing companies worldwide use MPDV’s innovative software solutions every day. These include renowned companies from all industries. MPDV currently employs 500 people at 13 locations in China, Germany, Luxembourg, Malaysia, Singapore, Switzerland, and the USA.

About PerfectPattern

PerfectPattern, the technology and software company based in Munich, was founded in 2012. The company develops software solutions that combine mathematical algorithms for process optimisations with Artificial Intelligence. This combination enables an automatic planning of any production process in real time - the Smart Factory is now reality. Three basic objectives are pursued: Flexibility, on-time delivery, and reduction of production costs.

PerfectPattern has developed with PYTHIA and CORTEX two revolutionary AI technologies. PYTHIA is a platform product for pattern recognition, time-series prediction, and anomaly detection in real-time data streams. Through the innovative combination of methods, including deep learning, stochastics, and quantum field theory, it independently finds even the most hidden patterns. CORTEX is a decision-making technology, which makes decisions based on the global objective functions by means of reinforcement learning.

PerfectPattern maintains relevant strategic partnerships with, among others Cimpress, Kodak, Sappi Europe and Voith.



MPDV
We Create Smart Factories

MPDV is the market leader for IT solutions in production. We offer products, solutions and services based on a broad expertise. MPDV supports companies from all industries and of all sizes on their way to the Smart Factory.

"We" stands for around 500 employees of MPDV. After all, it is the people who define a company. Every day, MPDV's teams develop smart manufacturing solutions. They have made MPDV what we are today with their passion for high-quality products, their knowledge and their team spirit: the market leader for IT solutions in manufacturing with more than 40 years of experience in the production environment.

"Create" stands for what MPDV is doing. We drive digitization in manufacturing and make companies competitive. We always have the finger on the pulse and know the needs of our customers very well. We operate competence centers, are in constant exchange with our users and further develop our solutions according to requirements. To do so, we focus on the essentials and thus stand out from the crowd.

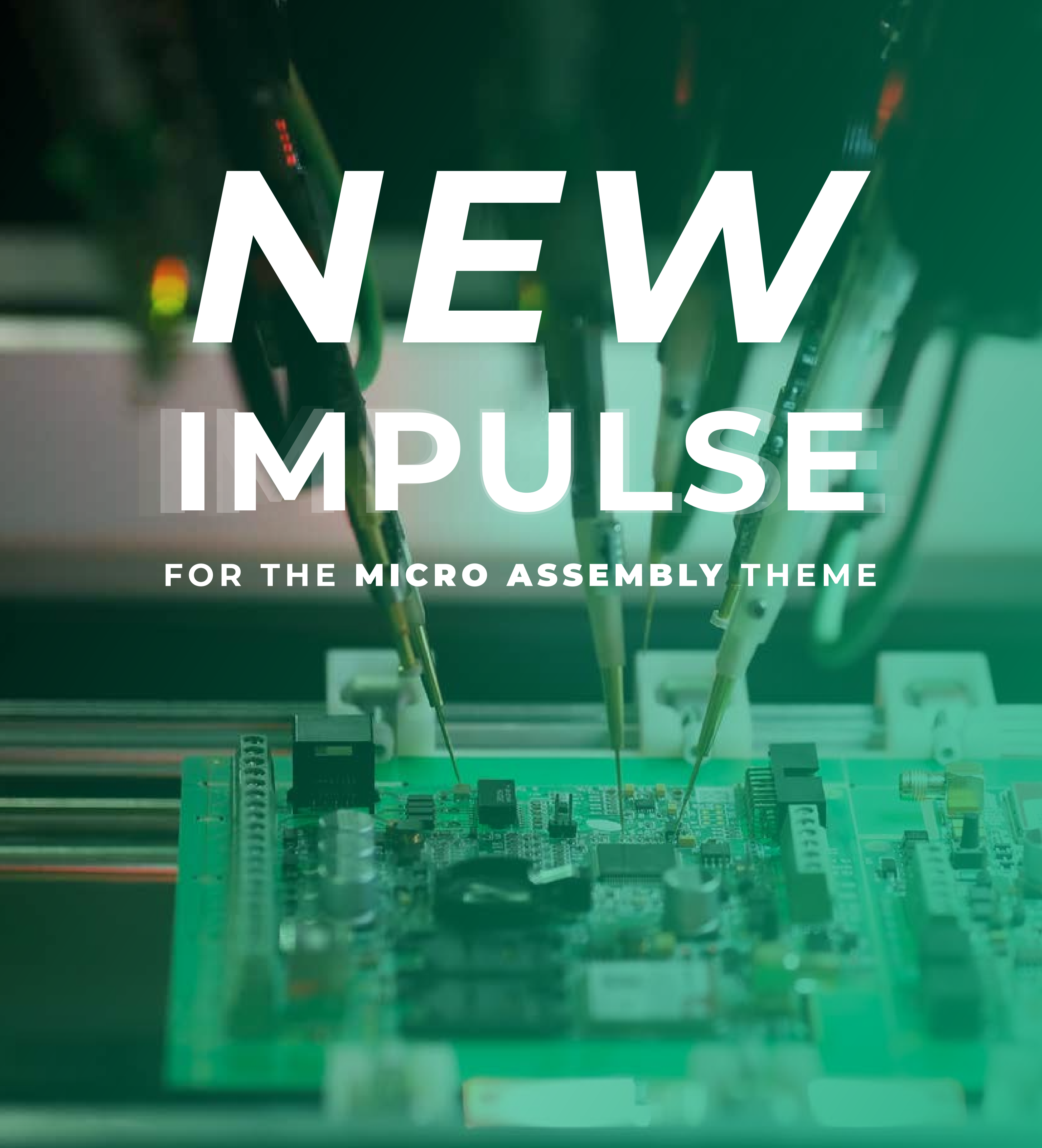
„Smart Factories" is the vision of a self-regulating factory of the future where machines and logistics systems organize themselves as independently as possible. MPDV supports companies in turning this vision into reality. We make a key contribution with our products to ensure that factories evolve into true Smart Factories and stay at the cutting edge of technology. The focus continues to be on people as an integral part of creating value.

The MPDV Group is made up of the following companies:

- MPDV Mikrolab GmbH and MPDV subsidiaries in China, Malaysia, Singapore, Switzerland and the USA.
- AIMES GmbH
- FELTEN Group
- Perfect Production GmbH

WE CREATE SMART FACTORIES

MPDV Benelux
Henry Woodstraat 65 ▪ 7558 CN Hengelo ▪ Netherlands
M: +49 162 2537 448 ▪ E: info.ne@mpdv.com
I: www.mpdv.com/de/mpdv-in-nederland/



NEW IMPULSE

FOR THE MICRO ASSEMBLY THEME

Authors:

Cas Damen

Professor NanoPhysics
Saxion University of
Applied Sciences

Anne Hurenkamp

Editor
Saxion University of
Applied Sciences

> *Precision Assembly involves placing and connecting components with an accuracy of several micrometers, sometimes even less.*

The large number of spin-off companies operating in the Twente region was one of the main reasons for setting up the Fraunhofer Project Center (FPC). Now that a number of these companies are aiming to scale up their production considerably, it is important that they can make full use of the knowledge and expertise of the partnerships within the FPC in the fields of production technology, digitalisation and precision assembly. Since spring 2021, the coordination of this last area of expertise lies with the NanoPhysics research group of Saxion University of Applied Sciences.

This research group has been partnering with the FPC for several years, but with this increased involvement it can now really accelerate the precision assembly research line within the center. Twente is an interesting region in that respect. There are many micro- and nanotechnology companies here that started product development a few years ago. Now they enter the next phase: scaling up production and the subsequent market introduction of their products.

In this next phase, the NanoPhysics research group, responsible for the Precision Assembly domain at FPC, is an important driver that can bring all relevant parties together. This research group has a large network of companies who can benefit from the new technologies, but also have access to the knowledge and lab facilities of the Fraunhofer Project Center for the further development of those companies. This is also the role of the FPC: to develop new technologies together with universities and other research collaborators to make them available to industry.

What is Precision Assembly?

Precision Assembly involves placing and connecting components with an accuracy of several micrometers, sometimes even less. Examples are microfluidic chips where exact amounts of gases or liquids must be delivered at exactly the right place. If the alignment of the components is not good, the system does not function. Also for integrated photonics, where light must be introduced into the waveguides of a chip at the right position, it is all about the very precise alignment and connection of various components necessary to control or read the chip. It is one of the processes that researchers from Saxion and the FPC are investigating together with companies in the region. Now a lot of assembly work is still carried out manually. The question is how this can be further automated, while maintaining – or preferably improving – the quality, making it possible to produce products with those chips faster and in larger quantities.

The demand for these types of products is already high, but is expected to increase considerably. For example, Point of Care devices, such as rapid testing to detect diseases (at an early stage) via a drop of blood or urine, can make a very relevant contribution to healthcare. Once they become available on the market, it will drive the demand for very large quantities of test chips, each of which will probably have to be assembled in cartridges.

The Precison Assembly programme line

With the lab facilities available at the FPC, researchers and students, under the direction of the Saxion research group, develop and test processes on a micro-assembly machine developed in Aachen, Germany. These processes are an important intermediate step in upscaling towards volume manufacturing: it is not yet about making millions of products, but about mapping out the right processes. The researchers will provide the knowledge gained from these studies to the companies. This allows them to actually shape the upscaling. The Precision Assembly programme line, which is now being steered from Saxion, is one of the technical domains that were set up in the collaboration between the Fraunhofer-IPT, the University of Twente and Saxion. Within this domain, the NanoPhysics group can use its substantive added value and network to boost research and associated applications with chip technology. In addition, the team has access to a wide network of research groups from both the University of Twente and Saxion, which can be engaged if specific knowledge is needed.

A double edge knife

An important reason for Saxion to be actively involved in this programme is the possibility to link various bachelor and master students to the research. The knife cuts both ways: the students are introduced to state-of-the-art machines and processes and at the same time, the results of their work are directly relevant to the companies involved. For example, in the past semester, three graduates worked with the machine in the lab at the High-Tech Factory located at the University of Twente campus. These students have developed a process to align a waveguide on a photonic chip with high accuracy in front of an optical fiber to have optimum light coupling. The required accuracy to establish this coupling is on the order of 1 micrometer. The special thing is that machine vision is used, finding the correct position based on an image taken with a digital imaging microscope within the system.

The future

The goal for the coming years is to build up enough expertise and knowledge to take a key position in the middle of the group of companies that are fully scaling up their production. Students and researchers, both from Saxion and the University of Twente, carry out the various studies, but always in close cooperation with the FPC, Fraunhofer IPT and the companies involved. Saxion can play the role as a stepping stone for companies towards the Fraunhofer Project Centre. In this way, everyone benefits. The institute has a machine that students have access to and love to work with. By working with the machine, they gain relevant knowledge. At the same time, the research team forms a link between all parties. To meet the growing societal demand for products based on chips, there is now a serious opportunity to take great steps forward.

Cas Damen's *NanoPhysics research group is carrying out research for the application of chips in special products, especially in sensors. It focuses on chips that are not based on microelectronics, but on* ***photonics, MEMS (micro-electromechanical systems) and microfluidics.*** *Subjects of research are the control and read out of these chips, their (large-scale) testing and the integration into larger units (assembly).*

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