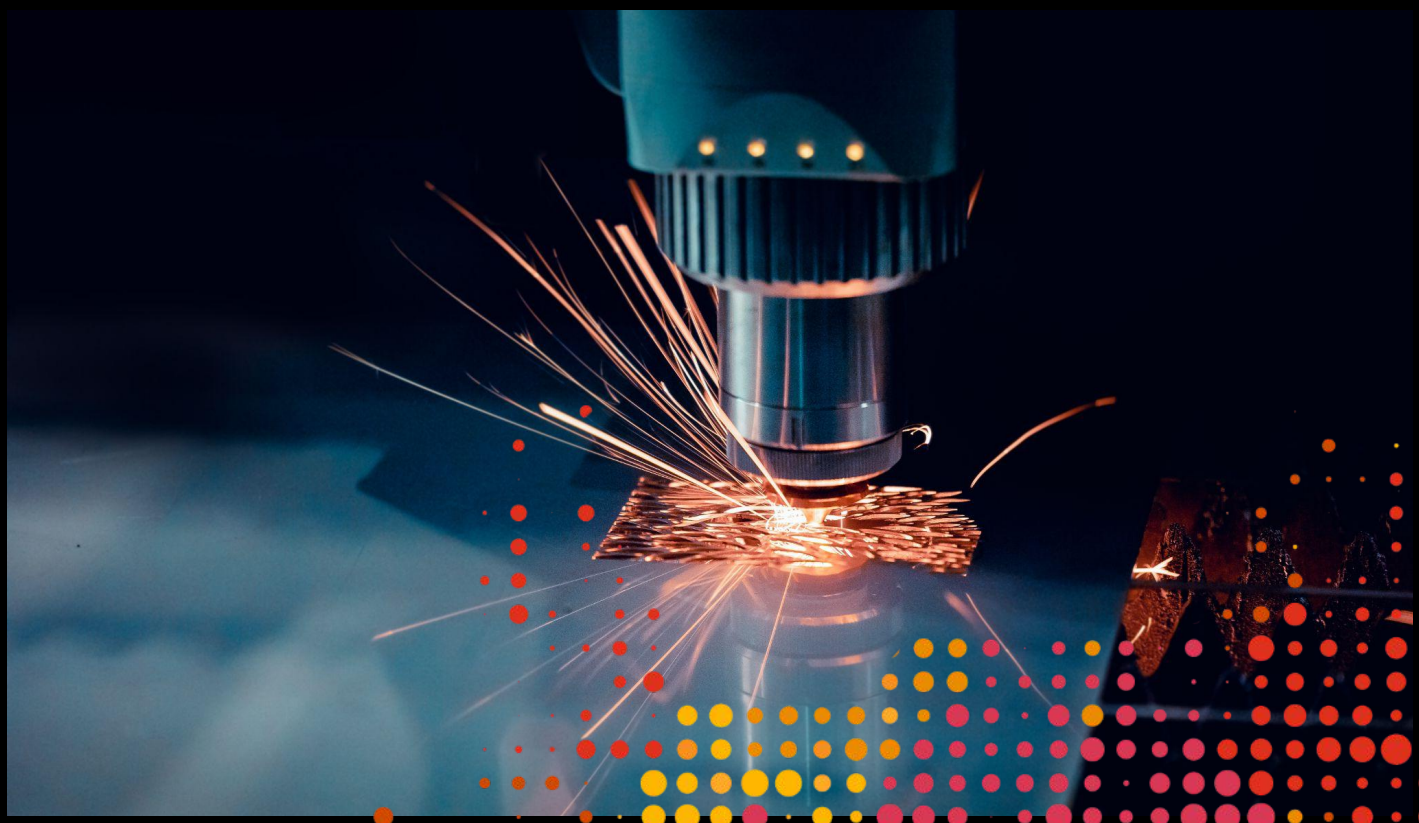
The game-changer – roles and impact of AI

Part of our Series “AI in the manufacturing industry”

Episode 2



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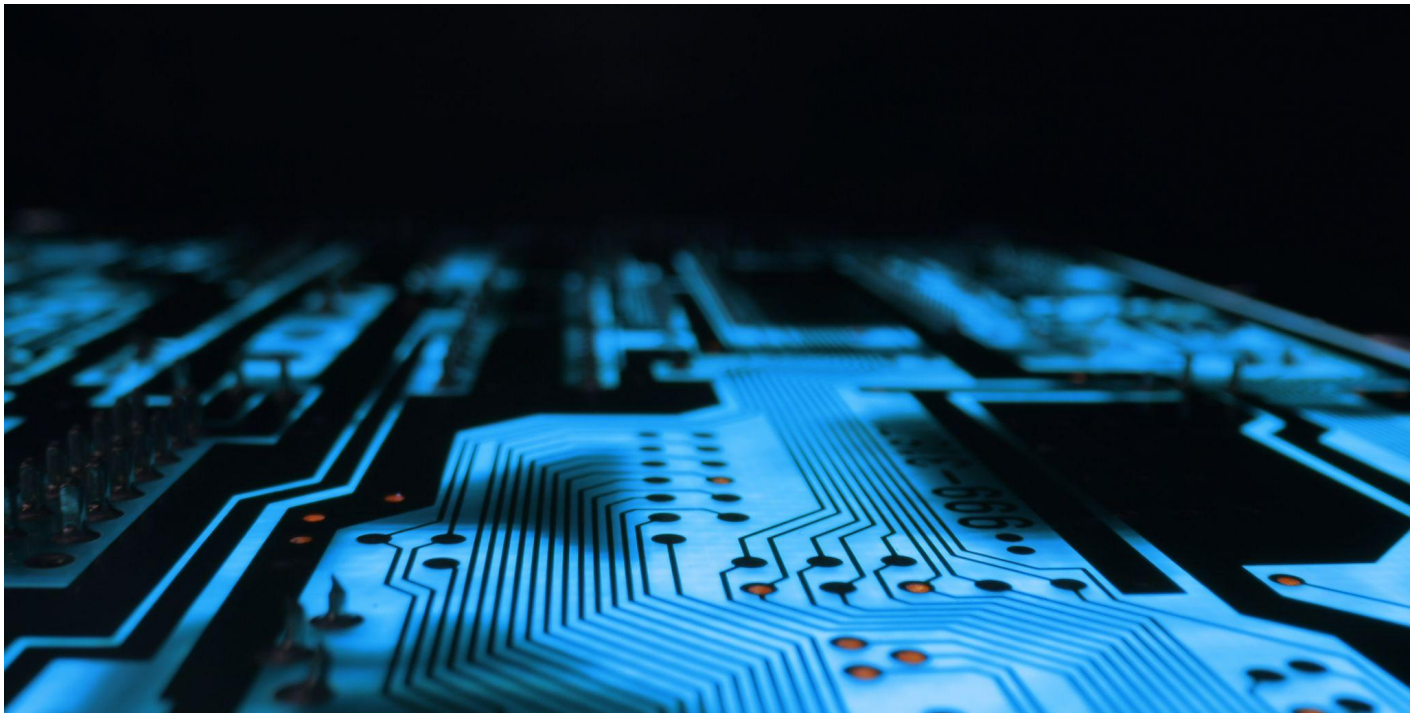
The series

Welcome to our series on the impact of Artificial Intelligence (AI) on the manufacturing landscape in Flanders and North Brabant, a joint project by PwC and OMC, the Open Manufacturing Campus. Our goal is to provide you with a comprehensive understanding of how AI is reshaping manufacturing and how it helps manufacturing companies improve their performance, innovation and sustainability, based on real world use cases from different sectors and regions.
We also share our insights and experiences on how to implement AI solutions successfully, addressing the technical, organisational and ethical challenges involved. Each episode delves into a specific aspect of AI, ensuring you gain valuable knowledge and actionable takeaways.
Throughout the series, our “AI in a nutshell” reference sheet provides the reader with an explanation on terminology and some fast facts.



This episode

The integration of AI into the manufacturing industry has emerged as a pivotal driver for operational excellence and innovation and strengthens a company’s competitive edge. As AI technologies continue to evolve, their applications within the manufacturing sector are becoming increasingly specialised and diverse. This article delves into the multifaceted roles AI plays in enhancing manufacturing operations and categorises its impacts on businesses.

These two aspects come together in a framework to navigate AI applications.
Note: this episode was made in collaboration with AI tools.

Categorisation of AI applications in manufacturing

Categorising AI applications presents a unique challenge due to the multifaceted nature of its implementations. While various frameworks exist to classify AI applications, the boundaries between categories are often blurred. This is because AI technologies can be perceived from multiple perspectives. For one, there is the classic categorisation of AI based on AI technology (e.g. computer vision, NLP) as we present in the AI in a nutshell reference sheet. Another example is the risk based categorisation of AI systems used by the European Union in their legal framework on AI (the EU AI act), which ensures Europeans can trust what AI has to offer (more details here). However, this series is looking into the applications of AI in the manufacturing industry, so we want to provide an angle on how these innovations contribute to manufacturing processes. We will adopt two different, but complementary, perspectives in the presented framework, namely the impact and role of AI applications.

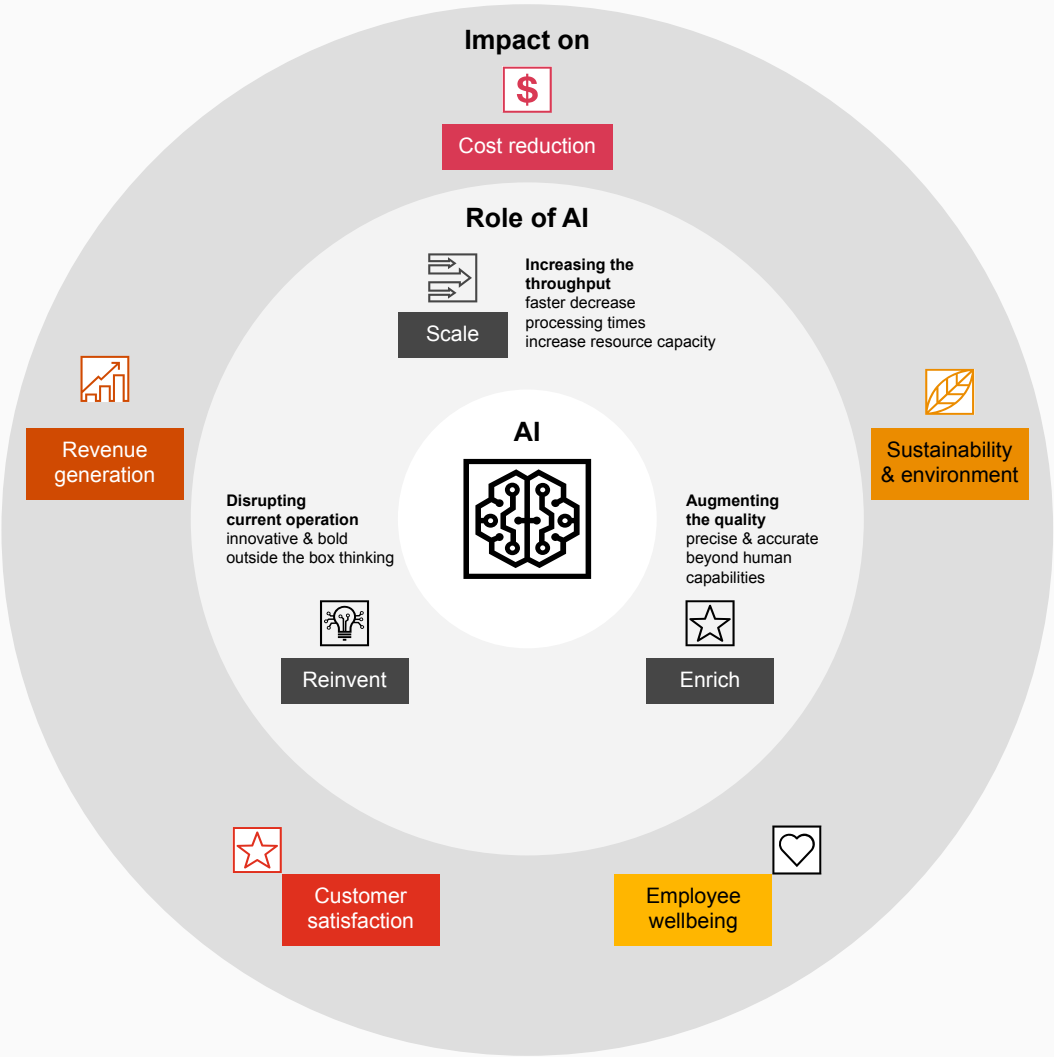
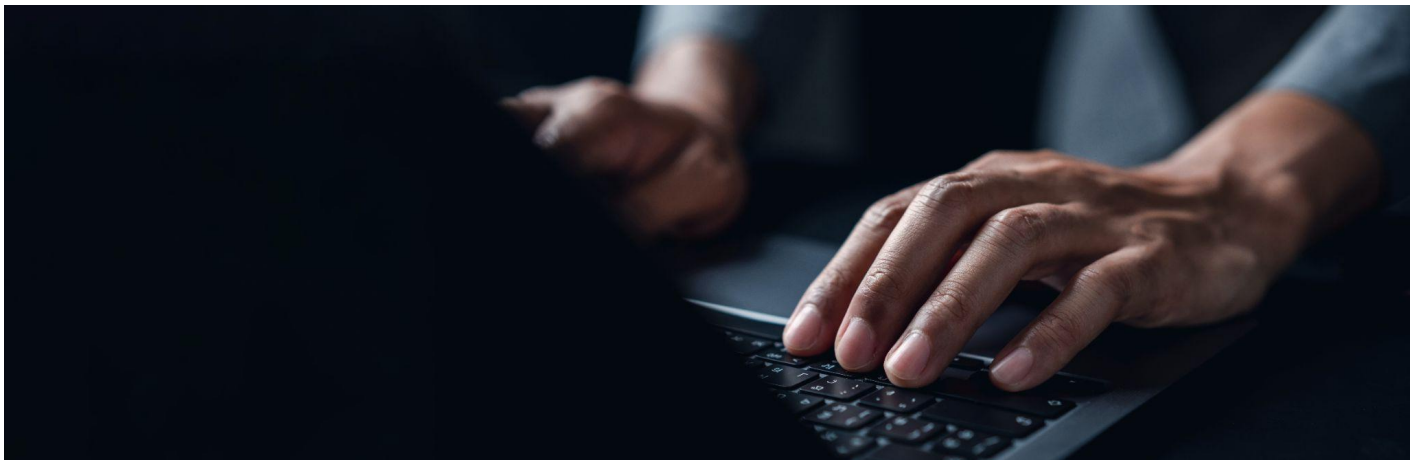


Figure 1: The role-impact framework

The Impact of AI

Firstly, we categorise AI by the performance indicators which are impacted through the adoption of it. While most AI applications will have a positive impact on more than one performance indicator, having a clear understanding of which performance indicator you want to target primarily is crucial for successful implementation. It is part of the AI project objectives and provides direction for the project team. To facilitate this, we have categorised the performance indicators into 5 areas: cost reduction, revenue generation, customer satisfaction, employee wellbeing and sustainability & environmental impact. Before diving deeper into each of the areas, it is worth noting that impact areas of AI are closely linked to performance indicators tracked by operational excellence strategies. For instance, the QCDSM performance metrics (Quality, Cost, Delivery, Safety, Morale), used in lean methodology focus on delivering high-quality products, on time and at a competitive cost to improve customer satisfaction as well as improving safety standards and increasing staff morale to increase employee wellbeing. Just like other digital tools, AI technologies should not be seen separate from operational excellence, but rather as a valuable tool in the pursuit of operational excellence.



1. Cost reduction

Implementing AI applications can lead to significant cost savings for businesses. Firstly, across functional domains, AI can handle repetitive tasks, freeing up employees to focus on more strategic work, which boosts productivity and reduces labour costs. Additionally, AI offers specific cost reduction opportunities for each functional domain.

Some examples are:

- helping predict when equipment might fail, allowing for timely and proactive maintenance and preventing costly breakdowns and interruptions in production,
- ensuring consistent quality in products by monitoring production closely, which reduces waste and the expense of reworking defective items,
- optimisation of inventory levels, ensuring that businesses don't overstock or run out of essential materials, saving on storage and procurement costs, and
- streamlining supply chain operations to minimise delays and reduce logistic expenses.

As well as core functional domains reducing costs through AI, supporting functions can profit from it. Again, some examples are:

- analysis of customer data to improve marketing strategies, making them more effective and less costly,
- automation of customer service, providing timely responses and reducing the need for large support teams, and
- enhancement of energy management in facilities, cutting down on utility bills.

Lastly, AI can help identify inefficiencies in business processes, allowing for continuous improvement and cost savings over time.

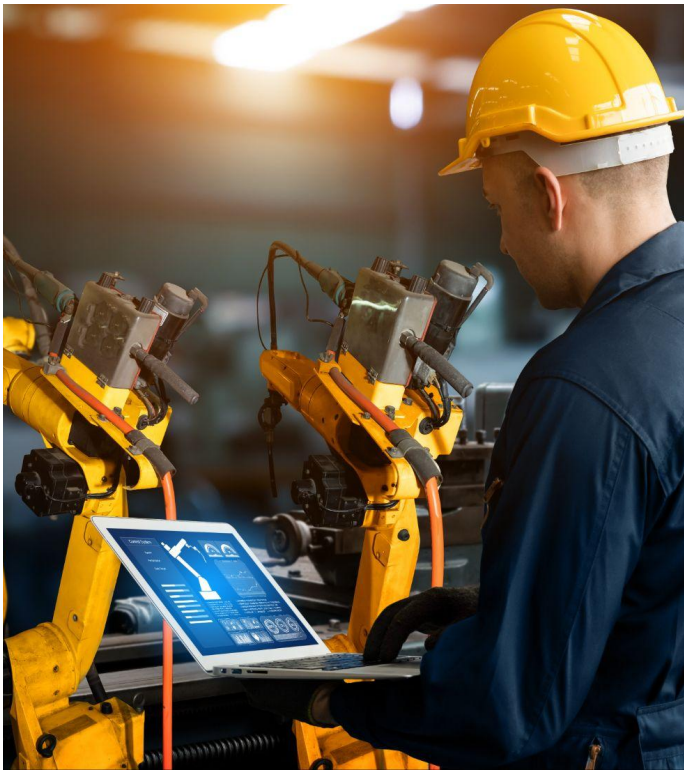
2. Revenue Generation

On top of reducing costs, AI applications offer opportunities to enhance revenue by opening new market opportunities and optimising pricing strategies to remain competitive. They enable the creation of innovative products or services, which generates new sources of income. AI also allows companies to adopt the 'Product-as-a-Service' (PaaS) model, providing continuous support and maintenance that ensures a steady revenue stream. Furthermore, AI facilitates mass customisation, allowing businesses to efficiently produce personalised products that cater to individual customer preferences. This not only attracts new customers but also fosters loyalty among existing ones by meeting their specific needs.

3. Customer satisfaction

AI is becoming vitally important in impacting customer satisfaction in today's increasingly competitive landscape. Firstly, AI can provide valuable insights into customer preferences and behaviours, helping businesses to anticipate needs and adjust offerings accordingly. This proactive approach ensures that customer expectations are consistently met, fostering long-term relationships and repeat business. Another impact of AI on customer satisfaction is by ensuring high-quality products and services. The Kapernikov case study at the end of this episode illustrates how AI can be scaled for quality measurements, ensuring that products meet customer expectations consistently. Finally, AI can support customer service agents in various ways to increase the quality and responsiveness of customer support.

4. Employee wellbeing



AI applications significantly contribute to enhancing employee wellbeing in various ways. By taking over dangerous tasks, AI-powered robots ensure a safer working environment, thereby reducing the risk of injuries. Moreover, AI tools can streamline routine tasks and decrease effort to produce new content and work on unstructured data, easing the workload and allowing employees to focus on more engaging and meaningful activities. Additionally, AI tools help in preparing first drafts and generating options to start from, which enables employees to reach a satisfactory outcome faster. This shift not only minimises stress but also fosters a more satisfying work experience. The overall impact is a healthier work-life balance and a more motivated workforce, which are crucial for long-term business success, especially in the demanding

5. Sustainability & environmental impact

AI's impact on sustainability and the environment in the manufacturing industry is profound. On the positive side, AI technologies enable manufacturers to optimise resource usage, reduce waste and lower energy consumption. For example, AI algorithms can analyse production data to identify areas where materials are being overused or wasted and recommend adjustments to reduce consumption. Furthermore, by simulating different manufacturing scenarios, digital twins can help companies explore more sustainable practices without the need to experiment in the real world. This can lead to significant reductions in emissions and environmental footprints. AI can also enhance supply chain transparency, allowing companies to monitor and manage the environmental impacts of their suppliers and ensure they adhere to sustainable practices.

However, the adoption of AI in manufacturing is not without its challenges. The environmental cost of producing and maintaining AI infrastructure, such as servers and data centers, can be significant. These facilities require substantial amounts of energy and resources, which can offset some of the sustainability gains achieved through AI. Moreover, the disposal of outdated or obsolete AI hardware can contribute to electronic waste if not managed properly. These resource consumptions are often hidden costs for companies as most AI tools are run in the cloud. The computing power and server capacity is typically used by different organisations and deployed as a service, which spreads the cost and makes it difficult to clearly quantify. Additionally, many initiatives are still in an experimental phase resulting in a less efficient use of the technology and resources on all dimensions. On the other hand, large cloud service providers are heavily investing in green energy to lower the impact of their data centers. In general, more clarity is needed on the environmental impact of AI. By balancing the benefits of AI-driven sustainability opportunities with the need for responsible resource management, manufacturers can make meaningful strides toward a more sustainable future.

Roles of AI

Until now, we have focused on the impact of AI implementations in the manufacturing industry. In this section we switch our perspective from impact to role. We make the distinction between 3 types of roles that AI can play in improving manufacturing operations: scaling, enriching and reinventing. Each of these roles offers distinct opportunities to improve operations and drive strategic growth.

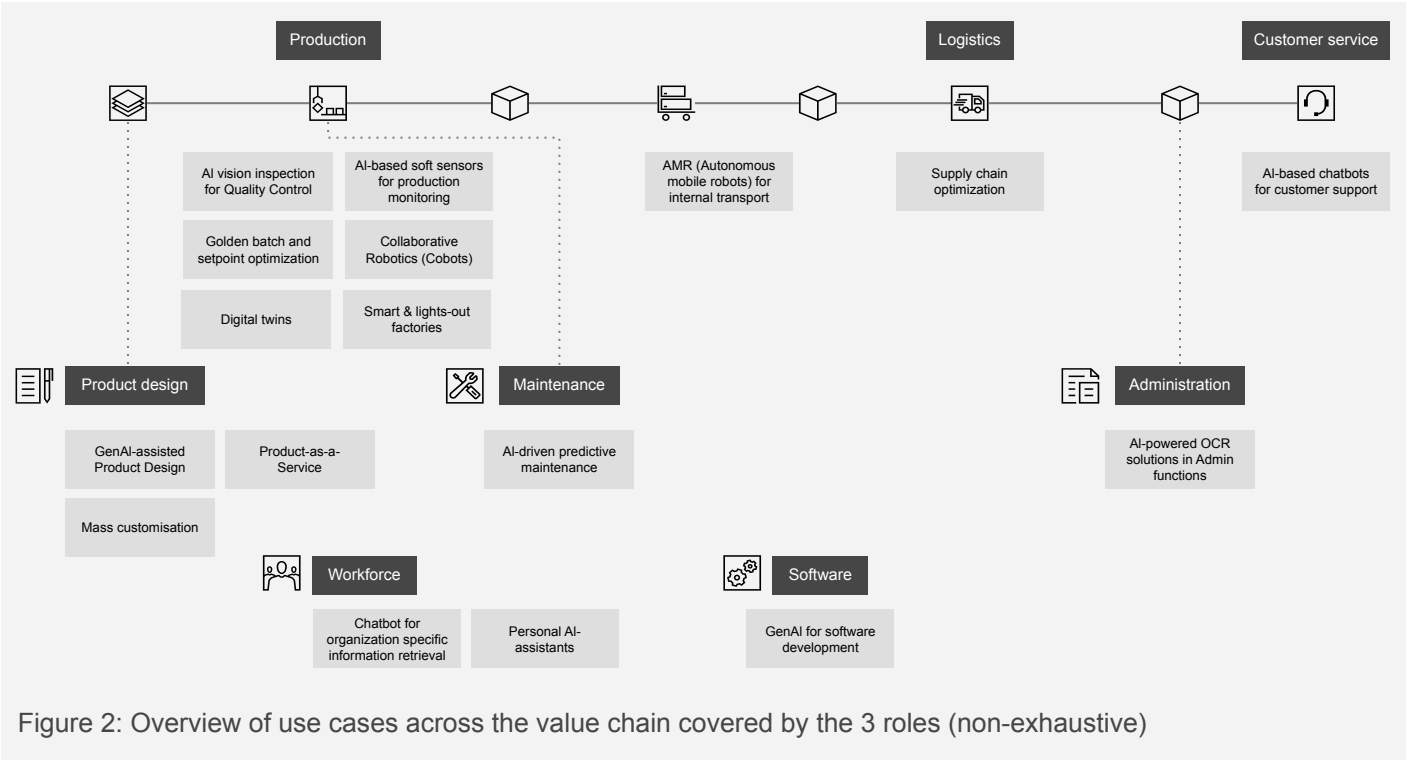


Figure 2: Overview of use cases across the value chain covered by the 3 roles (non-exhaustive)

1. AI at scale

As mentioned in the AI in a nutshell reference sheet, AI refers to the simulation of human intelligence in machines, meaning they are designed to think and act like humans. Additionally, with the ability to process large amounts of data in short timeframes and 24/7 availability, the opportunity to scale your current operations using AI becomes evident. AI at scale refers to the deployment of AI technologies across multiple facets of manufacturing operations to increase the throughput of activities. Think about the speed at which AI makes decisions, solves optimisation problems and discovers anomalies when performing activities for which we used to be dependent on human intervention. These capabilities can be leveraged by companies to decrease processing times and/or increase resource capacity. Let's make this concrete with some examples:

- **AI-driven predictive maintenance:**
  there are 3 advantages of AI for failure prediction. Firstly, AI algorithms are faster in analysing data sets, which speeds up the development of the prediction model. Secondly, prediction models using AI algorithms can identify unusual pattern or anomalies, which might go unnoticed with more traditional prediction models. Finally, these models are continuously learning and enhancing their predictive accuracy based upon real time data. All of this increases the prediction accuracy of the model, allowing it to better predict equipment failures before they happen, reducing unexpected downtime and extending the life of machinery.

- **AI vision inspection for quality control:**
  through the combination of computer vision to analyse objects and AI models to detect inconsistencies or defects, AI vision systems can detect quality issues in real-time, at a faster pace, with higher accuracy and without getting tired. This facilitates 100% inspection strategies without needing an excessive number of resources and ensures that only products that meet quality standards reach the customer. Find out more on how Kapernikov supported their client on the implementation of a vision-based quality inspection system in the case study attached to this episode.

- **Supply chain optimisation:**
  with supply chains becoming more and more complex to manage, AI is used to forecast demand, optimise inventory levels and manage logistic networks. These repetitive tasks can be automated by AI systems in real time on a continuous basis. This leads to more efficient and responsive supply chains.

- **Autonomous mobile robots (AMRs) for internal transport:**
  thanks to their intelligent navigation and decision-making abilities, AMRs are more flexible than autonomous guided vehicles (AGVs). Where AGVs require infrastructure changes, AMRs can sense their environment and navigate autonomously in dynamic environments offering flexible, automated 24/7 transport. This is especially valuable in scale-up environments where there is constant change in layout, tasks and volumes handled.

- **AI-based chatbots for customer support:**
  leveraging NLP and machine learning algorithms, chatbots respond to customer inquiries in a human like manner. This service is always available to customers, can handle multiple requests simultaneously, alleviating customer service agents from addressing routine questions. This allows agents to focus on more complex customer issues. Overall, AI-based chatbots reduce waiting times for customers and increase the capacity of the customer service department.

- **AI-powered OCR solutions in admin functions:**
  AI algorithms can convert scanned documents and images into editable and searchable text. This eliminates the need for manual data entry by accurately extracting information from various documents. By automating the data capture process, administrative tasks become more efficient, reducing errors and freeing up valuable resources to focus on higher-value activities.

- **AI-based soft sensors for production monitoring:**
  soft sensors replace physical sensors or manual measurements in cases where direct measurement is costly, difficult or prone to wear and tear. They predict real-time production parameters by analysing historical and live data. AI algorithms elevate their accuracy.
- **GenAI for software development:**
  GenAI is leveraged in software development through advanced machine learning algorithms which automate code generation, debugging and testing. By learning from vast datasets of code, it can suggest optimisations and detect potential errors early in the development cycle. This accelerates the development process, reduces human error and allows developers to focus on the conceptual decision-making of how the code should run. Additionally, GenAI can assist in creating detailed documentation and facilitating code reviews. Overall, this will dramatically increase speed of development.

Figure 3: The role impact framework illustrated with scale use cases

2. AI as an enricher

As discussed in the previous category, AI is a great asset for scaling operations. However, for some operations, it might not be required to scale the operations, but rather to augment the quality of the output. Here, AI's role is to enrich operations. More specifically, AI can enhance human capabilities by providing tools that augment decision-making, creativity and innovation. This role of AI focuses on complementing human capabilities rather than replacing them. A great example of this is how Reynaers Group developed an AI solution providing feedback and guidance to operators on complex operations (see case study episode 1). More use cases where AI enriches the human mind are listed below:

- **Golden batch and setpoint optimisation:**
  golden batch manufacturing identifies setpoints (input parameters) which optimise the production output given specific circumstances. Traditionally, this is done by replicating historical setpoints which proved successful in similar circumstances. AI augments the optimisation by understanding complex relationships between historical input and output parameters. This enables better identification of the most influential setpoints as well as suggesting unknown setpoint combinations. Operators can use these AI suggested combinations during process control activities. AI-driven setpoint optimisation continuously adjusts production settings to maintain optimal conditions, enhancing the overall process efficiency and product consistency to maximise yield and quality.
- **Chatbot for organisation specific information retrieval:**
  chatbots designed for information retrieval are mind-blowingly efficient in supporting all kinds of workers in navigating knowledge bases. By leveraging retrieval augmented generation (RAG), these chatbots understand user questions and can respond using organisational specific content. For example, a maintenance technician doubting the procedure to fix a specific asset, can ask the chatbot for the standard operating procedure (SOP) instead of looking through the database manually. Such a chatbot can return full SOPs but also specific steps or reference values in case of more precise questions. These use cases are instrumental in knowledge transfer to new resources and in providing workers with the right information at the right time.
- **GenAI-assisted product design:**
  while AI can assist engineers in various stages of product design it's especially powerful during the conceptual design. The ability to generate images from textual descriptions in seconds allows for exploration in diverse directions and quick design iterations, where engineers can focus on the creative side but are supported in mock-up visualisation by the GenAI tool.
- **Personal AI assistants:**
  the implementation of an AI assistant supports workers in time-consuming non-value adding tasks such as drafting and summarising documents, creation of meeting minutes and the generation of to-do lists.
- **Collaborative robotics (cobots):**
  designed to work alongside humans, cobots have been supporting workers in performing repetitive and hazardous tasks for a while now. The incorporation of AI in their systems enhances their real-time decision-making capabilities, allowing them to adapt to changing environments and learn from experience. Concretely, these cobots can, for example, support in heavy lifting, enabling workers to focus on more complex and creative aspects of manufacturing.

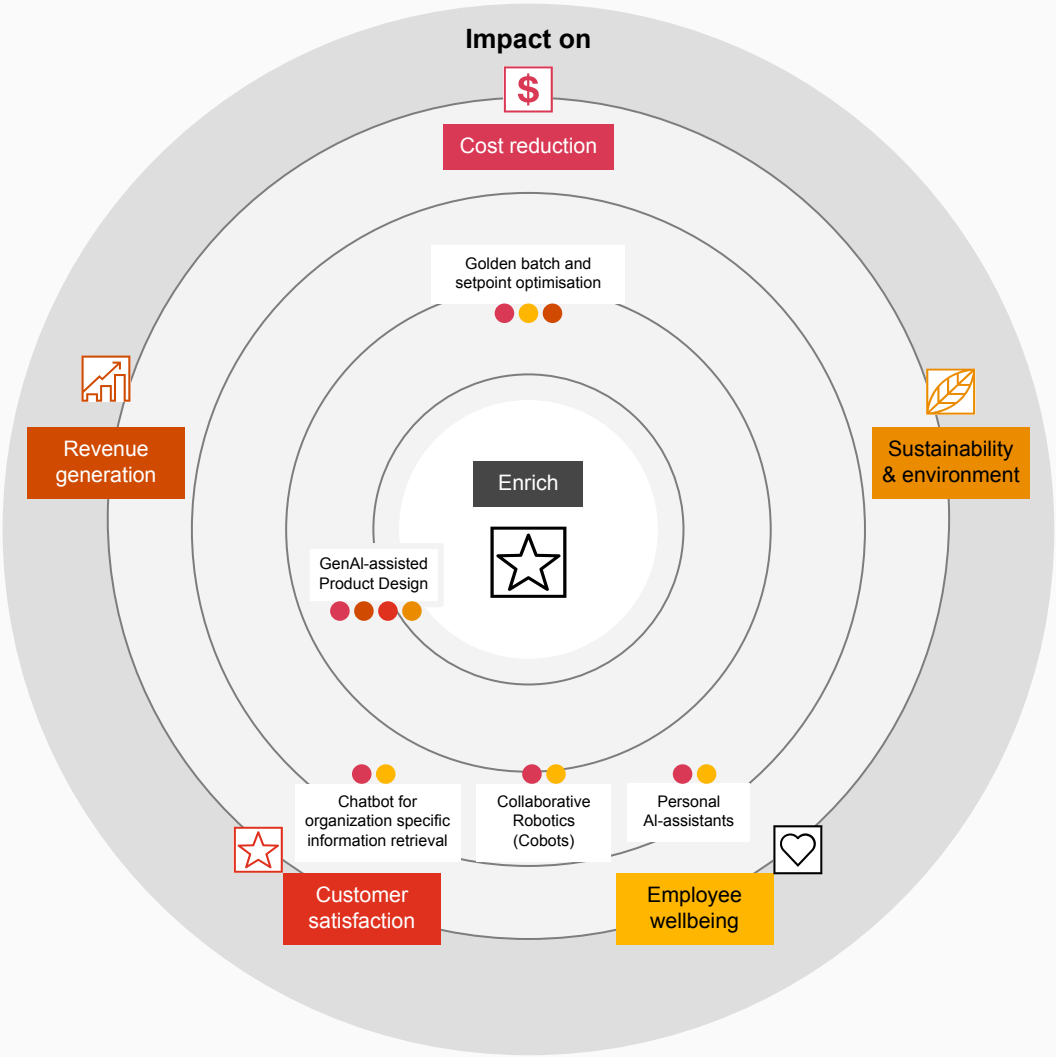


Figure 4: The role impact framework illustrated with enrich use cases

3. AI reinvents

As well as scaling and enriching current operations, AI can radically transform how businesses create, deliver and capture value. In these cases, AI disrupts current operations. Identifying such opportunities requires outside the box thinking since it's no longer about rethinking current operations but rather reinventing operations. Consequently, this is the role of AI which is still in its infancy in the manufacturing industry as companies are only now starting to take the first steps in disrupting their business through AI. We see the following broad categories that companies are exploring:

- **Smart and lights-out factories:**
  implementing AI to create highly automated and interconnected manufacturing environments where machines, systems and humans communicate and collaborate seamlessly.
- **Mass customisation:**
  AI enables manufacturers to produce highly personalised products at scale, catering to individual customer preferences without sacrificing efficiency (e.g. AI design tools combined with 3D printing).
- **Product-as-a-service (PaaS):**
  companies can use AI to shift from selling products to offering products as a service, using data to provide ongoing maintenance and support (e.g. power by the hour or compressed air as a service).

- **AI-enhanced Digital Twins:**
  AI enables faster creation of virtual replicas of physical assets and enriches the created models, allowing companies to simulate operations, optimise processes and explore new business opportunities in a virtual environment before implementing them in the real world.

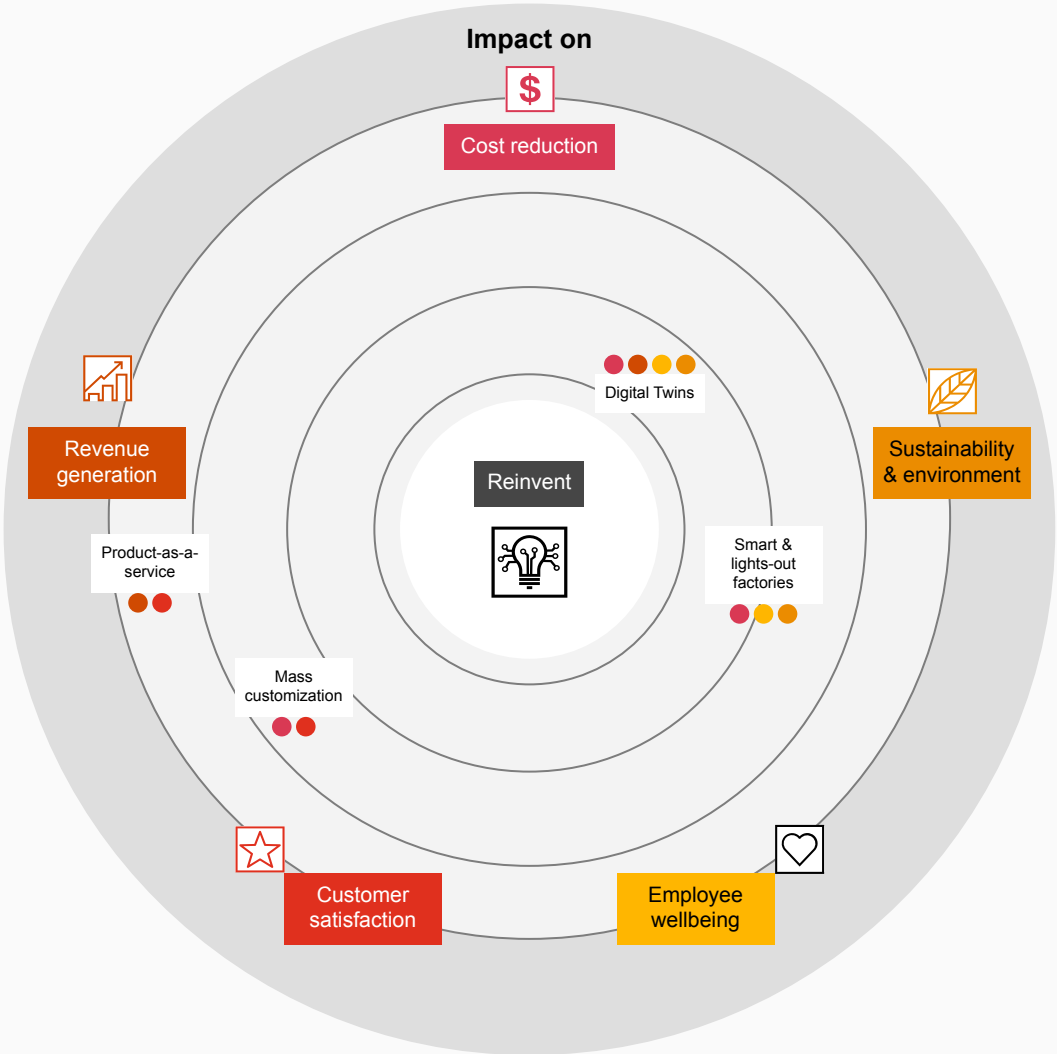


Figure 5: The role impact framework illustrated with reinvent use cases

The role-impact framework

As mentioned in the introduction, many frameworks to categorise AI applications exist. Here, we have chosen to highlight the impact and role of AI because combining them results in an easy-to-use framework when navigating potential AI initiatives within your company. While episode 5 will delve deeper into how to get started with AI in a practical manner, an important aspect is to ideate and prioritise use cases. Here, the role-impact framework provides a starting base for brainstorming exercises, guiding participants to investigate diverse directions. Additionally, the framework can be used to select and prioritise use cases, forcing you to keep the business needs and objectives in mind, avoiding the implementation of AI for the sake of keeping up with the trend.

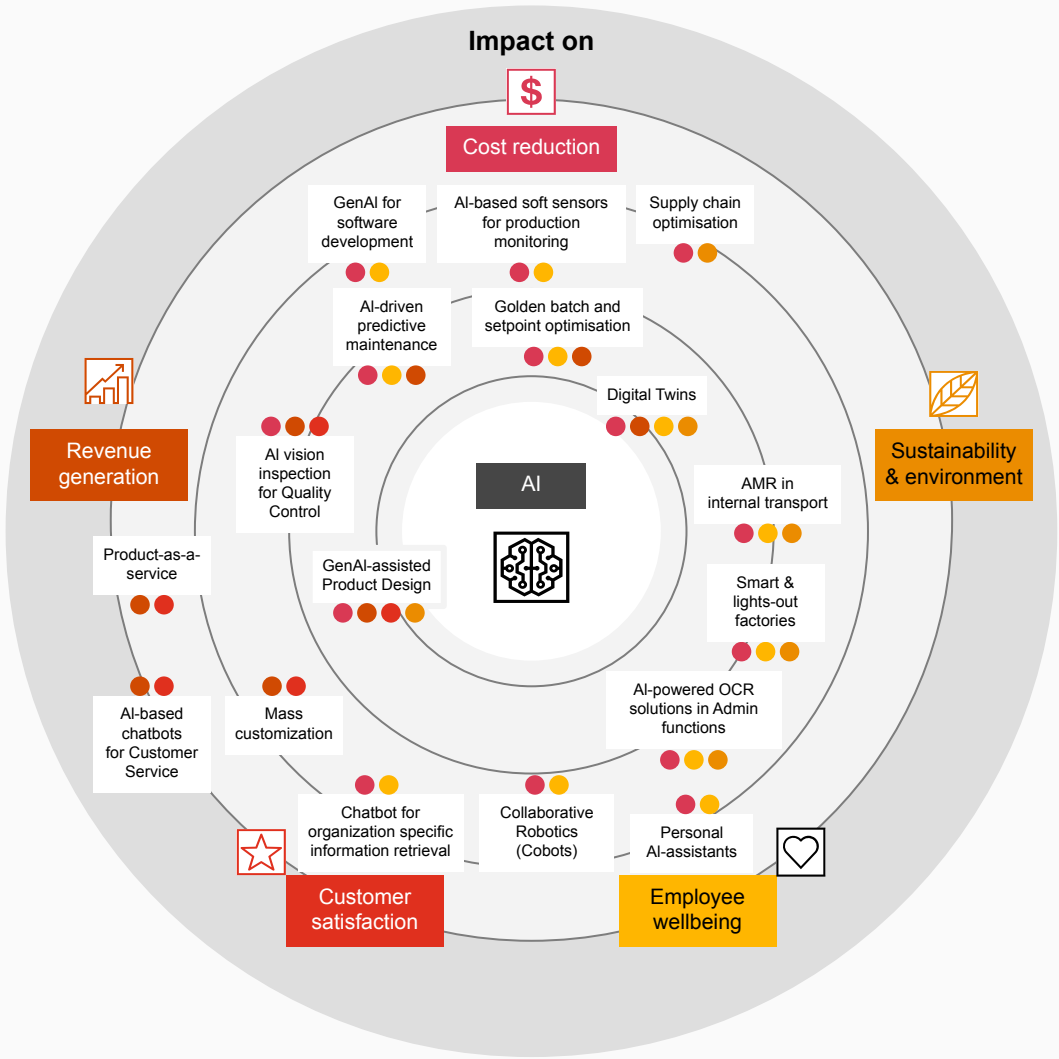


Figure 6: The role impact framework illustrated with the discussed use cases

Another way to inspire ideation sessions on potential AI initiatives is by exploring what other companies are doing. As an example, we provide here the Kapernikov case which highlights scaling of quality measurements to increase customer satisfaction.

Computer vision | Machine learning

KAPERNIKOV

REVOLUTIONISING QUALITY INSPECTION WITH VISION AI BY KAPERNIKOV

CONTEXT

A prominent player in the construction industry, was on the brink of a significant digital transformation. Facing rising expectations to elevate product quality, optimise operations and maintain a competitive edge in a swiftly changing market, the company recognised the need for advancement. Although they had already implemented strong quality control processes, it became evident that there was substantial value to be gained from enhancing their quality control methods to meet the increasing demands of their production lines.

CHALLENGE

The construction industry player faced notable challenges in upholding high-quality standards for their end products. The manual inspection processes were not only time-consuming but also susceptible to human error, resulting in inefficiencies and potential quality concerns. Furthermore, there were doubts about the scalability of these processes and their adaptability to new production demands. These challenges underscored the necessity for an advanced, AI-driven solution to optimise quality inspection, minimise manual effort and facilitate smarter decision-making throughout the organisation.

AI SOLUTION

To overcome these obstacles, Kapernikov developed a vision-based quality inspection system. This innovative solution utilises cutting-edge computer vision techniques and deep learning models to precisely assess critical quality parameters of intermediate product, including flock size, density and dust. The system's implementation involved several key steps:

Image Capturing and hardware setup: a high- resolution monochrome industrial camera and industrial-grade LED panels were employed to capture detailed visual data. Various lighting configurations, such as backlight, front light and a combination of both, were tested to enhance image quality. The final setup featured two or four LED lights positioned just outside the camera's field of view to provide intense backlight, ensuring clear visibility of both small and large flocks.

AI image postprocessing: classical machine vision techniques, including thresholding and contour detection, were utilised to analyse the captured images.

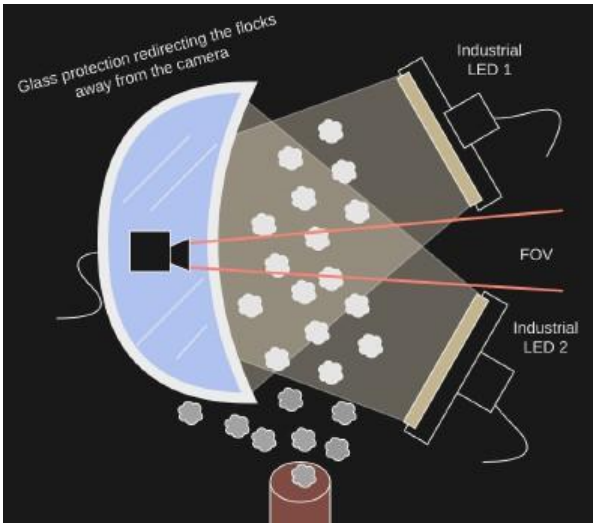


Figure: lighting setup with two backlights just outside the field of view of the camera

When classical methods fell short, deep learning-based instance segmentation models were trained on manually annotated images to accurately identify and segment the flocks. This enabled the determination of flock size and density based on the resulting images.

IMPLEMENTATION APPROACH

The deployment of the vision-based quality inspection system was methodical and collaborative, involving the following steps and incorporating the DMAIC methodology of Lean Six Sigma to ensure comprehensive quality control:

Discovery and assessment:

- Workshops evaluated the quality control processes, identified challenges and prioritised use cases for the vision AI system.
- Using DMAIC, critical-to-quality process variables for the end product were identified and critical quality attributes (CQAs) were determined and linked to critical process parameters (CPPs).
- Voice of the customer, AS-IS mapping and capability analysis were included.

Pilot phase:

- A pilot program tested the vision AI system in a controlled environment, allowing for adjustments before full-scale deployment.
- Significant influence factors were identified, and an improvement plan with digital solutions was developed.

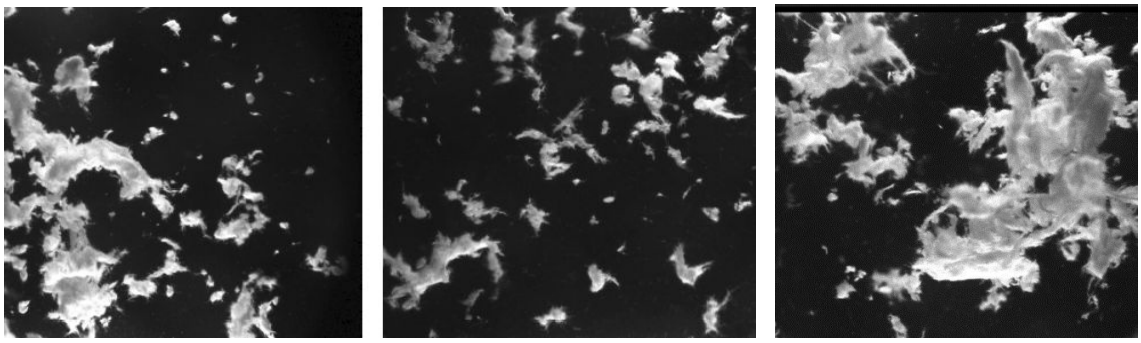


Figure: images captured with the double backlight setup with flock flow adaption

RESULTS AND IMPACT

The introduction of the vision-based quality inspection system was proven to significantly impact quality operations:

- The AI system provided precise measurements of flock size, density and dust, resulting in higher quality products.
- Automation reduced manual effort and enabled real-time production adjustments, thereby increasing efficiency.
- Data-driven insights facilitated smarter decision-making, optimising production parameters.
- The system's flexibility allowed the manufacturer to adapt to new production requirements and scale their operations effectively.

LESSONS LEARNED

Throughout the project, PwC, Kapernikov and their client gained some key insights on the implementation of AI projects:

- Implementing Vision AI in quality inspection can significantly enhance the accuracy and efficiency of processes.
- The Lean Six Sigma framework is suited to guide the adoption of AI solutions, offering a structured approach to enhance efficiency and drive continuous improvement.
- Continuous evaluation and iteration are crucial when integrating new technologies. Feedback from initial implementations should be used to refine and improve the system for optimal performance.

CONCLUSION

Kapernikov and PwC supported a key player in the construction industry in their digital transformation to enhance their quality inspection processes using AI-driven solutions. The manufacturer faced challenges with manual inspection processes that were time-consuming and prone to human error. A pilot program tested the vision AI system, which was later successfully deployed across production lines, resulting in higher quality products and increased efficiency through automation. Continuous evaluation and iteration were crucial for refining and improving the system into a successful solution which reduces costs and improves customer satisfaction.

Closing

AI is revolutionising the manufacturing industry by delivering impact across various dimensions (cost reduction, revenue generation, customer satisfaction, employee wellbeing and sustainability and environmental impact) and through diverse roles (scaling, enriching, disrupting). Given the versatility of the topic, adoption of AI can become rather complex. Fortunately, companies can tap into the ecosystem of AI players to guide and support them in this challenge. The next episode will dive deeper into this topic. Stay tuned!

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