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ARTIFICIAL INTELLIGENCE FOR MACHINE TOOLS

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FOREWORD

AI in the manufacturing sector has shown groundbreaking potential. The integration of AI in supply chain management, quality control, and predictive maintenance has improved efficiency and productivity. The creation of smart factories, minimising operational costs and facilitating superior scalability, are just a few of the benefits that AI will bring into our industry. One thing is certain: AI can enable a new era in the manufacturing sector, offering new opportunities, as well as challenges.

Therefore, a supportive legislative framework is needed to enable research, development, and testing of AI technologies. The European Union should strategically support AI deployment to enhance competitiveness. Collaboration, investment, and a skilled workforce are crucial for realizing AI's benefits in manufacturing.

We hope that this paper will be a valuable resource for those seeking to understand the impact of AI on our sector, its intrinsic value, but also its complexities.

Filip Geerts
CECIMO Director General

ARTIFICIAL INTELLIGENCE FOR MANUFACTURING

In recent years, **Artificial Intelligence (AI)** has shown the potential to impact the work and growth of many sectors. Manufacturing is one of those sectors that can potentially reap large benefits from the integration of AI in various domains, such as supply chain management, quality control, and predictive maintenance, which have brought significant improvements in efficiency and productivity. The future of AI could bring smart factories, that are highly automated and can adapt to changing production requirements.

Machinery products using this technology are already available on the market and in service. Leveraging AI and machine learning can help manufacturers to improve operational efficiency, launch new products, customise product designs, and address challenges such as unexpected machinery failure or defective product delivery.

The deployment of these solutions represents an opportunity to improve the competitiveness of the European Union. Nevertheless, the potential for the manufacturing industries to continue to reap these significant benefits will rely on a legislative framework that allows manufacturers to further research, develop and test AI technologies in their production processes. It is fundamental for our sector that the proposed legislation will strategically support the European manufacturing industries in their deployment of AI to strengthen their competitiveness and innovative capabilities vis-à-vis the other largest economies.

ARTIFICIAL INTELLIGENCE IN THE EU

AI has the potential to be a key technology for economic development in the European Union, and its integration into industrial processes is a priority for the EU and its Member States. The AI Act has the opportunity to set out a first-of-its-kind legislative framework on Artificial Intelligence and will shape how AI is developed and deployed in Europe, influencing indirectly other countries' legislation.

In 2021 European Commission's proposed Artificial Intelligence (AI) Act attempts to regulate a wide range of AI applications, aligning them with EU values and fundamental rights through a risk-based approach. The scope, instruments, and governance framework introduced by the proposal are still being debated and refined by European co-legislators.

The act has been presented as a 'horizontal' piece of legislation, even if several limitations and exemptions apply. This, combined with the expected, pervasive impact of AI on the economy and society, may lead it to overlap with several legislative provisions – both horizontal and sector-specific. As a result, gaps and inconsistencies might negatively affect legislative quality, regulatory certainty, and compliance.

CECIMO Recommendations

The AI Act proposed by the European Commission would be an important step towards establishing a legal framework for the development and deployment of AI in the EU. Nevertheless, there are different provisions outlined in the EC proposal that could potentially undermine our sector's ability to compete and maintain technological leadership in the long-term, particularly for the small-scale manufacturers. For example:

- **Limit "high-risk" classification of embedded AI systems to safety-relevant components**: If industrial machinery embedding AI systems remains within the scope of the AI Act, the high-risk classification should remain limited to safety-relevant components.
- **Limit the use of the third-party conformity assessment:** Third-party conformity assessment is a costly procedure that can inhibit innovation, and thus the possibility of internal production controls (Manufacturers' self-declaration) should be expanded in accordance with Annex II.
- **Leave common specifications as a limited "fall-back" option**: The power to introduce common specifications via implementing acts should be applicable on a temporary basis, and subject to strict and unambiguous conditions.

ARTIFICIAL INTELLIGENCE IN MACHINE TOOLS

In machine tool manufacturing, the application of industrial AI has steadily increased over recent years although the capabilities of industrial AI in the sector remain at a relatively early development stage as compared to other AI application that can perform tasks requiring human-level intelligence.

Machine tools are essential for the manufacturing sector as they enable the production of high-precision parts and components. The integration of AI in machine tools has enabled the development of smart machines that can learn from their environment and optimise their performance. This has resulted in faster and more efficient production processes, leading to cost savings and improved product quality.

A key subfield of Artificial Intelligence is machine learning which uses data and algorithms to simulate learning paths in machines and generate self-improvement and accuracy of processes. Machine learning can be applied to CNC machines in particular to the cutting forces, to predict the life span of the cutting tool as well as to facilitate the prediction of tool wear occurrence (i.e., the gradual failure of cutting tools due to regular operations).

Benefits of AI Applications in the Machine Tools Industry:

AI is being increasingly used in the machine tool manufacturing sector to improve productivity, reduce costs, and enhance overall efficiency. Here are some of the ways in which AI is being used in this industry:

- **Quality control**: AI can be used to monitor the production process in real-time and detect any defects or anomalies, ensuring that the final product meets the desired quality standards.
- **Optimisation of machining parameters**: AI algorithms can be used to optimise machining parameters such as cutting speed, feed rate, and tool selection, based on the material being machined and the desired outcome.
- **Autonomous machining**: With the help of AI, machine tools can be made to operate autonomously, with little or no human intervention. This can improve efficiency and reduce labour costs.
- **Supply chain optimisation**: AI can be used to optimise the supply chain, by predicting demand, optimising inventory, and identifying potential bottlenecks in the production process.

Improved human-robot collaboration: AI can be used to implement more successfully the presence of cobots in industrial environments, thereby reducing accidents and injuries to operators.

The challenges of Using AI in the Machine Tools Industry:

Despite the wide range of applications and the benefits obtained, industrial AI is mostly concerned with the implementation of specific tasks that require only a limited form of intelligence, inevitably subject to a narrow set of constraints and limitations established through man-made programs and algorithms.

While AI can offer significant benefits for machine tool building, there are also some limitations that must be considered:

- **Data quality**: AI algorithms rely on large amounts of data to learn and make accurate predictions. If the data used to train the algorithm is incomplete or inaccurate, the algorithm may not be able to make accurate predictions. For this reason, the integration with the data economy and the related legislative initiatives is fundamental to fully exploit the AI potential.
- **Complexity**: AI algorithms can be complex and difficult to understand, making it difficult for operators to troubleshoot problems or make modifications to the algorithm. Consequently, it is crucial to invest in talent attraction and skills development.
- **Cost**: Implementing AI in machine tool building can be expensive, requiring significant investments in hardware, software, and personnel training. Hence, funding is needed, especially directed to SMEs to facilitate their digital transition.
- **Technical expertise**: The implementation of AI in machine tool building requires technical expertise that may not be available in-house. Manufacturers may need to hire additional personnel or partner with outside experts to implement and maintain AI systems.
- **Security**: AI systems can be vulnerable to cyber attacks, making it important to implement strong security measures to protect sensitive data and prevent unauthorised access.

Overall, while AI offers significant benefits for machine tool building, manufacturers must carefully consider the limitations and potential challenges associated with its implementation to ensure its success. Therefore, these elements make clear the importance of a harmonised approach that covers all the key dimensions of the digital transformation, i.e., data and cybersecurity above all.

STANDARDISING AI IN MANUFACTURING

Standards development is particularly important for AI in manufacturing because it can help to ensure that AI systems are developed and deployed in a way that supports quality, consistency, safety, reliability, interoperability, and compliance with regulatory requirements and industry standards.

Being a rapidly evolving field, the use of AI with new technologies, algorithms, and applications emerging at a rapid pace, makes it difficult to develop standards that remain relevant over time. In addition, the complexity of the subject and the limited data available for testing and validation makes the development of standards a real challenge.

The challenge to develop international standards for AI has been carried out by the IEC and ISO joint technical committee (SC 42).

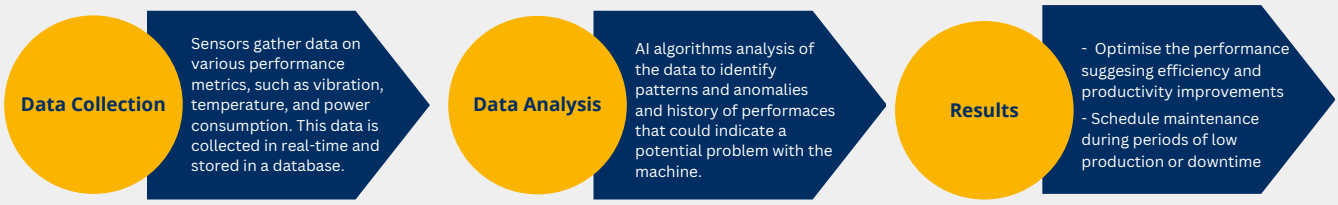
Two recent foundational standards for artificial intelligence will provide important building blocks for digital transformation. ISO/IEC 22989 covers AI concepts and terminology, and ISO/IEC 23053 describes a generic framework for using machine learning (ML) technology.

POSSIBLE USE CASES OF AI IN MACHINE TOOLS

Use Case 1 - Predictive Maintenance

Relevance: Use of predictive maintenance to improve machine performance and sustainability

Predictive maintenance (PdM) is a strategy that uses data analysis tools and techniques to detect and predict anomalies in an industrial operation and possible defects in equipment and processes, so they can be fixed before they fail, thus allowing manufacturers to schedule downtime and prevent unexpected breakdowns.



Positive Effects

Increasing sustainability and business efficiency

- PdM enables the sustainability of manufacturing systems in different ways by eliminating the threat of equipment degradation, reducing downtime, the need for spare parts and waste of materials and energy. PdM can help reduce the cost of repairs by identifying and addressing issues before they become more serious. Furthermore, it increases the level of processes' safety by recognising potential safety hazards before they occur.

Better data-driven decision-making

- PdM provides valuable data and analytics that can help inform decision-making and improve overall operations. In addition, it allows the development of new services with the collected data and derived models (for example: training of operators and local maintenance staff).

Use Case 2 - Optimisation of Machining Parameters

Relevance: Enhanced efficiency, quality, and cost-effectiveness.

Machining parameters refer to settings used by machine tools for cutting, shaping, and finishing materials into desired forms. Such parameters include cutting speed, feed rate, depth of cut, tool geometry, and so on. Conventionally, manufacturing parameters have been determined through empirical evidence and this takes time and money. With AI's help, manufacturers can quickly optimise them more efficiently and cost-effectively.

Positive Effects

Real-time improvement of quality in operations

- The optimisation of machining parameters using AI and in particular machine learning algorithms allows manufacturers to perform sensor data analysis on machine tools to adjust machining parameters in real-time to achieve optimised performance, leading to significant increases in both efficiency and quality in manufacturing operations.

Optimal outcomes by analysing historical data

- Machining parameters can be optimised using predictive analytics: AI algorithms can analyse past machining data to develop predictive models to help optimise parameters in future machining operations. These models take into account factors like material properties, tool wear rates, and cutting conditions to help predict an ideal combination of parameters that is likely to have optimal outcomes.

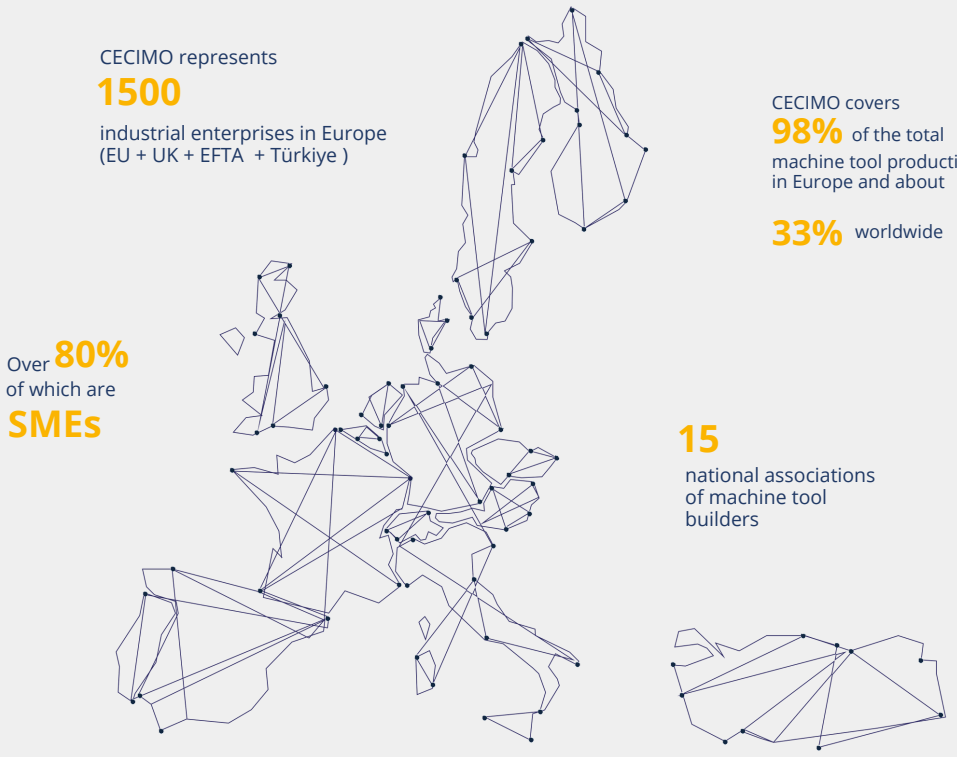
CONCLUSION

The use of AI in machine tools has enabled manufacturers to collect and analyze vast amounts of data, which can be used for predictive maintenance and quality control. This has led to a reduction in downtime, lower maintenance costs, and improved product quality, as defects can be detected and corrected before they cause any problem.

The integration of AI in machine tools will continue to grow and bring significant benefits to machine tool manufacturers. It provides them with a highly effective tool to optimise factory operations, enhance the productivity of machines and services, while simultaneously improving energy efficiency and resource utilisation. By leveraging AI capabilities, machine tool manufacturers can streamline processes, reduce downtime, and enhance overall operational efficiency, leading to cost savings and increased competitiveness in the market.

Nevertheless, regulatory standards and technical barriers to AI should be addressed in order to promote responsible and safe development and deployment of AI. By addressing these issues, the EU, the industry and other relevant stakeholders can help ensure that the manufacturing sector can use AI in the most beneficial and safe way possible.

CECIMO is the European Association of the Machine Tool Industries and related Manufacturing Technologies. We bring together **15** national associations of machine tool builders, which represent approximately **1500** industrial enterprises in Europe (EU + UK+ EFTA + Türkiye), over **80%** of which are SMEs. CECIMO covers about **97%** of the total machine tool production in Europe and about **1/3** worldwide. It accounts for approximately **150,000** employees and a turnover of around **25.1** billion euros in 2022. More than three quarters of CECIMO production is shipped abroad, whereas half of it is exported outside Europe.



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