11th International Conference on Electrical, Electronics and Computer Engineering (IcETRAN), Nis, 3-6 June 2024

# Ethical issues of artificial intelligence in modern metrology in the context of Industry 4.0

Vesna Vasilić
*Department of Power, Electronic and Telecommunication Engineering*
*Faculty of Technical Sciences, University of Novi Sad*
Novi Sad, Serbia
vesnavasilic12@gmail.com

Marjan Urekar
*Department of Power, Electronic and Telecommunication Engineering*
*Faculty of Technical Sciences, University of Novi Sad*
Novi Sad, Serbia
urekarm@uns.ac.rs https://orcid.org/0000-0002-6089-9148

***Abstract*—This paper discusses the use of artificial intelligence in the context of Industry 4.0, highlighting its advantages, disadvantages, and challenges in implementation. Special emphasis is placed on the potential consequences that could arise if production, decision-making, and measurement processes were entirely entrusted to the independent action of artificial intelligence. Additionally, ethical dilemmas arising from the increasing reliance on artificial intelligence in industrial processes are explored. The paper underscores the importance of awareness of risks and the necessary balance between the autonomy of artificial intelligence and human control, particularly in the field of measurement, to ensure sustainable and ethical development of the industry in the era of Industry 4.0.**

***Keywords—artificial intelligence, meausurement, Industry, ethics***

## I. INTRODUCTION

The massive use of digital technology has triggered a digital transformation of industry, leading to the term Industry 4.0, also known as the Fourth industrial revolution. The concept of Industry 4.0 represents the integration of advanced technologies, such as cyber-physical systems that communicate with each other using the Internet of Things, Internet systems, artificial intelligence and large amounts of data stored in the so-called clouds [1]. The accelerated technological progress of this revolution is increasingly shifting the boundary between tasks that are in the human domain and those that are taken over by machines and algorithms, which imposes the need to acquire new types of knowledge and skills. A context is created in which "smart" machines can communicate with each other, not only to automate production lines, but also to analyze and understand a certain level of production problems with minimal human involvement. Computers, which until now were in charge of controlling machines in production and storing data, are now capable of mutual communication and processing of different types of data using artificial intelligence technologies. This development marks a more advanced level of automation and digitization, where humans have been moved out of the production process. The term "smart" occupies a central position within Industry 4.0 and refers to independent and autonomous devices that are able to communicate in real time and cooperate in a smart environment with other smart devices, making decisions and performing actions based on the information obtained. In the concept of Industry 4.0, metrology plays a key role using advanced technologies to improve the precision, efficiency and reliability of the measurement process. The integration of technologies allows measurement devices and systems to be connected to digital networks, enabling the collection, analysis and sharing of data in real time. Modern metrology involves the use of intelligent measuring systems that can adapt, self-calibrate and perform automated measurements. These systems often use artificial intelligence algorithms to analyze data and detect anomalies, leading to improved accuracy and efficiency. Another advantage of metrology within Industry 4.0 is remote monitoring, where sensors and measuring devices are integrated into production lines, which enables continuous monitoring and feedback. The application of digital technologies in the field of metrology leads to an increased demand for high precision and quality in production, as well as the need for efficient measurement processes. Various industries, such as automotive, aerospace and medical, are actively using the principles and technologies of modern metrology to improve their production processes.

## II. ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is one of the key technologies driving Industry 4.0, introducing a digital and smart environment as the main paradigm [2]. Digital cities, smart factories, smart homes, smart cars, smartphones... Everything referred to as "smart" devices consists of sensors and algorithms that collect data from the environment, analyze, and process it for various purposes [3]. Artificial intelligence is increasingly becoming an integral part of various industries. The number of areas where it is applied has rapidly increased in recent years, from automating processes in industry to science, medicine, and education. Automation has expanded its influence into the field of metrology, where it is applied to automate the calibration processes of measuring instruments to ensure their accuracy and measurement reliability. Additionally, automation enables increased accuracy of measuring instruments, as well as data analysis to identify and correct possible measurement errors. This application of technology allows for more efficient and reliable measurement across different industries, contributing to the improvement of product and process quality.

This research has been supported by the Ministry of Science, Technological Development and Innovation (Contract No. 451 -03-65/2024-03/200156) and the Faculty of Technical Sciences, University of Novi Sad through project "Scientific and Artistic Research Work of Researchers in Technical Sciences, University of Novi Sad" (No. 01-3394/1).

One example of the application of artificial intelligence is in the oil and gas industry, whose facilities face many risks (system failure, fire, violation of environmental regulations) that can threaten the safety and operations of the oil industry. Using AI video analytics cameras, anomalies in the flame are tracked and detected, such as dark spots caused by soot or flame loss. This system uses artificial intelligence algorithms that analyze video footage in real time to identify irregularities or changes in the flame, which could indicate potential problems and hazards. When such an anomaly is detected, the system can automatically generate an alert or notify operators to take appropriate steps to solve the problem and prevent more serious incidents. These surveillance cameras are also used to monitor liquid levels in tanks using thermal imaging, detect leaks on tanks and pipelines using drones, automatically detect accidents, etc.

Fig.1 Thermal infrared cameras and video analytics for oil and gas installations and fire detection [4]

## III. Artificial intelligence in gas technology

In gas technology, correctors play a key role as measuring devices that monitor gas flow. Their basic function is to measure the current or past amount of gas [5]. Recently, advances in technology have allowed adjusters to provide detailed information on gas flow in real time, as well as consumption over a period of time. The application of artificial intelligence can improve these devices by making it possible to estimate the required amount of gas for the next day, especially for consumers such as district heating plants whose consumption depends on various factors. Artificial intelligence analyzed data on previous gas consumption and combined it with current information such as temperature, wind speed, sunshine hours and meteorological conditions to accurately predict the required amount of gas for the heating season. The advantage of applying artificial intelligence is that it enables stable gas consumption and potential financial savings. However, there are also challenges, such as synchronizing the corrector to estimate the required gas quantities on multiple supply lines, which requires regular maintenance and control of the device. Also, extensive testing is needed over a longer period in order to confirm the reliability of the price of the required amount of gas with artificial intelligence, given that gas consumption in city heating plants is present only during the heating season. This device could be integrated with weather forecasting platforms, which would enable automatic adaptation of operations to the device's changes in weather conditions. If this way of applying artificial intelligence proves useful, the same principle could be applied on a larger scale, such as an entire distribution or transportation network.

## IV. Ethical issues

The development of technology and artificial intelligence brings with it a huge potential for positive changes in society, but it can also cause certain challenges and risks. The question arises, where is the border between man and machine, between human and artificial intelligence. Education and awareness of ethical issues are key. Artificial intelligence today encompasses a wide area of application of the latest technological achievements to the intelligent solution of various types of problems. There is a legitimate fear of bias and discrimination in decisions made by artificial intelligence algorithms. Algorithms, which are critical to accurately measuring and maintaining quality in various industries, can transmit or reinforce existing social biases or discrimination, which can lead to unfair results in measuring or evaluating quality. If an algorithm, used to determine product quality in a factory, trained on historical data that reflects social inequalities, can produce results that do not take into account all relevant factors or discriminate against certain groups. For example, in medicine, artificial intelligence algorithms are increasingly being used to interpret medical images, such as X-rays, CT and MRI scans. There is a danger that algorithms, if not properly trained, may be biased towards certain demographic groups. For example, a lung cancer diagnosis algorithm may be less accurate when interpreting lung scans of women or in patients of a certain age group [6]. In industrial metrology, artificial intelligence algorithms play a key role in maintaining product quality in production facilities. These algorithms are often used to detect product defects, such as cracks, irregularities or damage. However, it may happen that such an algorithm is trained on the basis of previous data, which may not take into account all relevant product characteristics or specific production parameters. This can lead to a bias towards certain characteristics of products or manufacturing processes. For example, if an algorithm is trained on images of products of only a certain color or shape, it may not be effective in detecting defects on products of other colors or shapes. Delegating decisions to artificial intelligence can lead to people losing control of systems and processes and becoming dependent on the decisions made by artificial intelligence. For example, in traffic, self-driving cars would rely on artificial intelligence for navigation and changes in the environment. When such a vehicle is faced with a situation that requires immediate intervention or a choice between multiple options, the decision would be made based on artificial intelligence algorithms, without human influence [7]. Also, the air conditioning system in homes would automatically adjust the temperature according to the external conditions and user preferences, but decisions about when and how to adjust the temperature would be made based on data analysis and artificial intelligence algorithms. If a smart air conditioning system misinterprets the data and starts increasing the temperature on a summer day, the user would have no way to redirect the system or turn it off. Concerns arising from the possibility of artificial intelligence reaching or surpassing human capabilities are highlighted to an extreme degree.

If artificial intelligence takes over decision-making and taking over most tasks instead of humans, the question is how humans will adapt their roles and activities. In such situations, it is important to consider the need to set certain limits to ensure that people retain control over key aspects of work and functioning. Limitations should be put in place to ensure that artificial intelligence does not assume absolute power and to preserve human autonomy, ethical principles and social values.

This could include the development of regulatory frameworks, laws and standards that ensure that artificial intelligence works in accordance with the goals and interests of people, while respecting moral and ethical norms. In addition, it is important to invest in education to enable understanding and critical thinking about the role of artificial intelligence in society, as well as ways to manage its impact. In the process of eliminating bias in artificial intelligence systems, it is critical to ensure that algorithms are trained on diverse data sets that represent different demographics, cultural contexts, and perspectives. This helps prevent the appearance of bias that can arise from a lack of diversity in the data. Regularly testing the system for bias and correcting the results are also vital steps to ensure that any bias is identified and addressed before it has harmful consequences. Although artificial intelligence can provide and enormous benefits in various fields, it is important to remember that it is only a tool and not a substitute for human expertise, judgment and creativity. For example, in medicine, artificial intelligence can be useful in the analysis of medical images and diagnostics, but the presence of qualified doctors who can interpret the results, make diagnoses and recommend therapy based on their expertise and experience is still necessary. Similarly, in engineering disciplines, artificial intelligence can assist in process optimization and design, but human intervention is still critical for making decisions, solving complex problems, and ensuring system safety and reliability. This awareness of the role of artificial intelligence as a tool rather than a substitute for human expertise should guide the development and application of artificial intelligence in various fields. The integration of artificial intelligence with human expertise can result in the best possible solutions and improvement of various industries and sectors, while preserving the importance of the human role in the decision-making and problem-solving process [8][9][10].

Industry 5.0 represents not only technical progress, but also a paradigm shift in the way of thinking about production [11]. While Industry 4.0 was driven by automation and technological efficiency, Industry 5.0 emphasizes the importance of the human factor and the interaction between people and technology. This new era of manufacturing recognizes that automation is not always the best solution, especially in medium and small businesses, where market needs for personalized products are high and full automation may not be financially viable [12]. Instead, Industry 5.0 aims to integrate human creativity, flexibility and adaptability with technology to achieve efficient and personalized production. Industry 5.0 does not replace technology with human labor, but is aimed at creating synergy between humansand machines. Through this collaboration, people can use their creativity, intuition and emotional intelligence to improve production processes and provide products that are tailored to the individual needs of users. This approach also has wide application in plant maintenance, where human intervention may be necessary to identify and resolve complex problems that may arise. Industry 5.0 represents an adaptable and economical perspective that responds to the dynamic demands of the modern market. Rather than just being a technological advance, it brings a deeper understanding of how people and technology can work together in the most effective way. This new paradigm paves the way for innovation, personalization and growth of companies in the digital age, creating the opportunity for value creation and competitive advantage in the market.

The proposal is to advance modern metrology and measurements by applying the basic postulates and ethical implications of Industry 5.0, even if the field has not yet moved to Industry 4.0 or is planning to move to Industry 5.0. The reason for this is that the application of Industry 5.0 principles could already prevent problems that might otherwise arise in the future. Waiting to move to Industry 5.0 can be risky because by then it might be too late to prevent problems, and dealing with the consequences would require much more resources. The industrial sector should take over and apply the basic postulates of Industry 5.0 in practical measurements and metrology already now. This would allow the measurement processes to be improved, resulting in more accurate and reliable results. Also, the application of Industry 5.0 principles in metrology can lead to greater transparency, responsibility and sustainability in industrial processes. The basic postulates of Industry 5.0 include the connection of physical and digital systems, system autonomy, personalization of products and services, as well as the integration of man, machine and artificial intelligence. Taking into account all the above, taking steps towards the application of the basic postulates of Industry 5.0 in metrology and measurements already now can be crucial for improving the performance and competitiveness of the industrial sector in the future, as well as for preventing potential problems that might otherwise arise.

## V. Conclusion

Examining the impact of Industry 4.0 and 5.0 on metrology and measurement in industry reveals important implications and challenges. While Industry 4.0 brings advances in automation and digitization, Industry 5.0 emphasizes the integration of human capabilities with technology to achieve efficient and personalized production. Taking into account the speed of technological development and the need to adapt the industry, it is recommended to take steps towards the implementation of the basic postulates of Industry 5.0 already now. Implementation of these principles can improve measurement processes, increase accuracy and reliability of results, and enable greater transparency, accountability and sustainability in industrial processes. Also, adopting these principles early can help prevent potential problems that might otherwise arise in the future. Although artificial intelligence brings numerous benefits in various fields, it is important to preserve human autonomy, ethical principles and social values. Therefore, education and raising awareness about ethical issues related to the application of artificial intelligence is of crucial importance. Through the integration of human creativity and technology, Industry 5.0 presents a perspective that responds to the dynamic demands of the modern market and creates an opportunity for value creation and competitive advantage in the market.

## REFERENCES


[1] Christoph Jan Bartodziej, „Artificial intelligence in Industry 4.0“, year 2017.

[2] Artificial Intelligence taken from : https://www.sas.com/en_us/insights/analytics/what-is-artificial-intelligence.html

[3] Stuart J. Russell and Peter Norvig, „Artificial Intelligence - A Modern Approach”

[4] Thermal infrared cameras and video figure taken from: https://www.acalbfi.com/be/news-and-insights/thermal-infrared-cameras-and-video-analytics-oil-and-gas-installations-and-fire-detection

[5] Oil and agas industry taken from: https://www.investopedia.com/investing/oil-gas-industry-overview/

[6] Artificial intelligence in medicine taken from: https://www.foreseemed.com/artificial-intelligence-in-healthcare

[7] Artificial intelligence in self-driving cars taken from: https://www.here.com/learn/blog/ai-how-close-are-we-to-self-driving- cars

[8] Jyotir Moy Chatterjee, Harsh Garg, R. N. Thakur, „A Roadmap for Enabling Industry 4.0 by Artificial Intelligence“, year 2023

[9] Shashank Awasthi, Carlos M. Travieso-González, Goutam Sanyal, Dinesh Kumar Singh, „Artificial Intelligence for a Sustainable Industry 4.0-Springer“, year 2021

[10] "The Future Is Faster Than You Think: How Converging Technologies Are Transforming Business, Industries, and Our Lives" by Peter H. Diamandis and Steven Kotler

[11] Industry 5.0 taken from: https://www.forbes.com/sites/jeroenkraaijenbrink/2022/05/24/what-is-industry-50-and-how-it-will-radically-change-your-business-strategy/?sh=1feaf11f20bd

[12] Industry 4.0 taken from: https://www.weforum.org/agenda/2016/10/how-can-we-enjoy-the-benefits-of-the-fourth-industrial-revolution-while-minimizing-its-risks/