

# Innovative Personal Protective Equipment: Advantages and Disadvantages of Applying Artificial Intelligence

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## ABSTRACT

Personal Protective Equipment (PPE) plays a crucial role in ensuring the safety and health of workers in various industrial areas. With the advent of Artificial Intelligence (AI), new opportunities for improving the effectiveness and efficiency of PPE have arisen. In the proposed paper, will be examined the potential applications of AI in PPE, and will be evaluated the advantages and disadvantages of applying AI to PPE. In the introductory section, an overview of AI and its potential applications in PPE will be provided. Then we will examine examples of how AI has been industrialized in the production of PPE, including the use of sensors and advanced algorithms for monitoring worker health and safety. We argue that AI can be a powerful tool for improving the performance of PPE and reducing the occupational risks such as work-related injuries and illnesses. In the central section of the paper, will be evaluated the advantages and disadvantages of applying AI to PPE. We will discuss the benefits of using AI to enhance the precision and accuracy of PPE, as well as its potential to reduce the workload and costs associated with traditional PPE. However, will be also highlighted some of the potential drawbacks of AI in PPE, such as the risk of relying too heavily on technology, neglecting other important aspects of worker safety and ethical implications. In the last section of the paper, we will provide solutions for overcoming the limitations of AI in PPE. We argue that a balanced approach is needed, one that combines the strengths of AI with other approaches to worker safety, also considering ethic aspects. We suggest that future research should focus on developing hybrid systems that integrate AI with other technologies, such as wearables and augmented reality, to create more effective and user-friendly PPE. In summary, the paper proposed wants to provide a comprehensive analysis of the potential benefits and drawbacks of applying AI to PPE. We argue that AI has the potential to revolutionize the field of worker safety, but caution that a balanced approach is needed to ensure that the benefits of AI are realized without compromising other important aspects of workers' health and safety.

**Keywords:** Personal protective equipment, Artificial intelligence, Occupational safety, Workers' safety

## INTRODUCTION

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“The impressive capabilities of Generative AI created a sense of urgency for companies to reimagine their products and business models, industrial companies are racing to digitalize and reinvent into software-driven tech companies, to be the disruptor, and not the disrupted” (Huang, 2023).

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In the central section of the paper, will be evaluated the advantages and disadvantages of applying AI to PPE. We will discuss the benefits of using AI to enhance the precision and accuracy of PPE, as well as its potential to reduce the workload and costs associated with traditional PPE. However, the potential drawbacks of AI in PPE will be also highlighted, such as the risk of relying too heavily on technology, neglecting other important aspects of worker safety and ethical implications.

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## ARTIFICIAL INTELLIGENCE AND PERSONAL PROTECTIVE EQUIPMENT

Artificial intelligence (AI) refers to the development of computer systems or machines able to perform tasks requiring human-like intelligence, such as understanding natural language, learning, problem-solving, and recognizing patterns. In recent years, AI has advanced significantly, moving beyond simple machine learning algorithms to include deep learning capabilities, increased automation, and improved natural language processing. These developments have led to widespread adoption across various industries,

including healthcare, finance, retail, and manufacturing. AI systems are now capable of handling complex tasks such as image recognition, predictive analytics, and conversational agents. Furthermore, improvements in computing power, faster data transfer rates, and larger datasets have all contributed to the growth of AI applications. As the technology continues to evolve, it holds promise for even more innovative uses in personal protective equipment, workplace safety, and injury prevention.

The integration of Artificial Intelligence (AI) in Personal Protective Equipment (PPE) is a key aspect of the broader goal of Industry 5.0, which seeks to harness advanced digitalization, big data, and artificial intelligence to increase production flexibility, render value chains more robust, and promote sustainability (Breque et al., 2021). In this context, the integration of AI in PPE has the potential to transform occupational health and safety. By leveraging cutting-edge algorithms and machine learning techniques, organizations can enhance the performance of their PPE, improve workers' safety, and mitigate the risk of workplace accidents and illnesses (Awolusi et al., 2018). As the adoption of AI continues to grow, it is crucial that business leaders take a balanced and strategic approach to its integration across industries. It is important to remember that AI is just a tool - one that can aid and enhance existing practices but should not replace them entirely. With careful planning and consideration, AI has the potential to unlock new opportunities for growth and innovation, while simultaneously promoting a culture of safety and responsible data management.

## **PRACTICAL APPLICATION OF ARTIFICIAL INTELLIGENCE IN PERSONAL PROTECTIVE EQUIPMENT**

Artificial Intelligence (AI) has the potential to revolutionize the world of work, also for personal protective equipment (PPE) and industrial safety (Manyika et al., 2017). AI-powered PPE can significantly reduce the risk of work-related injuries and illnesses, improving the health and safety of workers. A growing number of companies are investing in AI technologies to enhance PPE design, monitoring, and management. In this section are presented some industrial projects that leverage AI to enhance PPE contributing to a safer and more productive work environment.

The first project of Industry 4.0 applied to PPE is the SENSE RISC project (Lanata et al., 2020). It is a wearable device developed by the Italian Workers' Compensation Authority (INAIL) to improve worker safety and prevent accidents in high-risk workplaces such as construction sites and industrial plants (Fig. 1). The device is equipped with sensors that can detect a variety of environmental and physiological data, such as temperature, humidity, heart rate, and motion. This data is then analysed to provide real-time feedback to workers and supervisors, enabling them to detect worker fatigue or stress, which can be early warning signs of accidents or injuries.

The use of artificial intelligence in SENSE RISC can enable the device to learn from past data and adapt to changing conditions, making it a powerful tool for accident prevention. The device can be customized to suit the needs

of different workplaces and industries and has the potential to revolutionize the way we approach workplace safety.



**Figure 1:** Smart PPE by project SENSE RISC (INAIL, 2020).

By harnessing the power of AI, IBM has developed the project Maximo Worker to provide real-time monitoring of worker safety, performance, and productivity. The wearables, equipped with sensors, collect data analysed by AI to minimize risks and optimize work processes (Smith, 2021). This technology wants to enhance workers' safety and efficiency while providing real-time visibility into operations.

Another high-tech industry, Intel with Portwell, has developed an AI system that utilizes computer vision to identify and prevent workplace accidents. The system uses cameras and sensors to check that employees are wearing the appropriate PPE when required, to monitor workers and equipment, and analyses the data in real-time to detect potential safety hazards (Fang et al., 2021). By detecting these hazards early, the system can alert workers and supervisors to use the best PPE, to take appropriate action and for preventing accidents and injuries.

An American company, Guardhat, has developed a wearable sensor system that uses artificial intelligence to improve worker safety and productivity (Patel et al., 2021). The system consists of a range of sensors, including accelerometers, gyroscopes, and environmental sensors, that collect real-time data on worker movements and environmental conditions. This data is then analysed by AI algorithms to identify potential hazards and provide recommendations to workers and supervisors. The system can also alert workers to hazardous conditions or equipment malfunctions and provide guidance on safe work practices. A recent study emphasizes that the use of AI-powered PPE enables such type of PPE to adapt to changing conditions and provide real-time feedback to workers, making it a powerful tool for enhancing workplace safety and efficiency (Campero-Jurado et al., 2020).

Various other companies, including Intellimech, Daqri, StrongArm Technologies, Solex Robotics, and Vuzix, are incorporating AI and sensor technology in personal protective equipment to improve safety and efficiency in industrial applications. Their products include smart helmets, wearable

devices, smart gloves, and AR glasses that monitor environmental conditions, detect falls, analyse worker movements, posture, and provide real-time information and alerts.

### **Application of Artificial Intelligence to Personal Protective Equipment: Advantages and Disadvantages**

Incorporating AI into PPE offers several advantages over traditional approaches. For instance, AI-powered monitoring systems can help employers keep close watch over their workers' wellbeing and spot potential hazards before they escalate. This enhanced surveillance can result in decreased exposure to various risks, including harassment and violence, as well as earlier detection of stress, health concerns, and exhaustion (EU-OSHA, 2021).

Another advantage is increased efficiency. By automating processes such as fit testing and maintenance scheduling, AI can be cost effective while also saving time and resources, ensuring that PPE is always up-to-date and properly fitted to each individual wearer. Furthermore, AI can help to optimize workflows and predict when additional protection may be needed based on environmental factors or job tasks, potentially expanding the lifetime of the equipment, and reducing the risk of errors (EU-OSHA, 2022).

AI processes vast amounts of data efficiently and accurately to enable informed decisions, which facilitate the design and production of tailored PPE that precisely fits each worker's specific physical characteristics and conditions. This, in turn, leads to increased comfort and security, which reduces the likelihood of accidents and injuries occurring, as workers are less likely to remove uncomfortable gear. In the event of an accident, wearing the correct fitting PPE can help minimize the severity of injury.

One significant benefit of incorporating AI into the production process of PPE is its ability to improve quality control. Using AI, vast amounts of data generated by sensors on the manufacturing line can be analysed, identifying any anomalies or defects that may have been missed by human inspectors. This results in higher-quality products being produced at a faster rate and allowing real-time monitoring of the entire manufacturing process.

However, despite these benefits, there are also some important considerations to keep in mind when it comes to using AI in PPE.

One of the main issues with AI-powered PPE is the risk of dependence on technology. Workers may become complacent and less likely to identify and respond to hazards if they rely too heavily on technology. Additionally, excessive reliance on technology can hinder workers' decision-making skills, leaving them ill-equipped to handle unexpected situations.

Employers must ensure that workers maintain situational awareness and the ability to react quickly to potential hazards.

As we continue to explore the drawbacks of integrating AI into PPE, another concern is the one surrounding privacy with the use of such technology. AI algorithms could be used to monitor worker behaviour or track their movements, which could potentially violate employee privacy. There is also the risk that sensitive data collected by AI systems could be compromised or leaked, leading to identity theft or other security breaches.

The use of AI in PPE might increase operational difficulties and lead to elevated user error rates due to confusion caused by the added layers of complex technology, particularly for those unfamiliar with the new systems, resulting in more errors during operations.

Another disadvantage is the high upfront cost of implementing this technology. This cost can be prohibitive for small to medium-sized enterprises (SMEs) as they often have limited financial resources compared to large corporations. Despite the long-term benefits of AI in PPE, SMEs may struggle to justify the immediate financial burden required for its implementation. Moreover, the lack of skilled personnel to manage and maintain the system could add complexity to existing challenges faced by SMEs in adopting AI in PPE.

Equally important is the significant limitation that AI is not entirely error-free. Inaccuracies in data input or algorithm design can lead to incorrect predictions or false alarms, which can result in adverse consequences for business operations. Moreover, AI systems may struggle to adapt to new information or unexpected scenarios, leading to suboptimal decision-making. This issue was highlighted in a recent study conducted by OpenAI that sheds light on the limitations of even the latest AI technology (OpenAI, 2023). The study found that the accuracy rate of GPT-4, which is considered one of the most advanced language models available, is only around 80%. This means that approximately 20% of the time, the answers provided by the model may be incorrect or incomplete. These findings serve as a reminder that AI is not perfect and that it is important to exercise caution when relying solely on machine intelligence for decision making.

A resolution by the European Parliament highlights the considerable ethical implications of integrating AI into PPE, particularly with respect to issues of bias and discrimination, responsibility and liability, and transparency and accountability (EU Parliament, 2020). The World Economic Forum (WEF) also emphasizes the need for responsible AI governance to ensure the integration of AI in PPE does not lead to the aforementioned limitations (WEF, 2019).

One of the primary concerns is the potential for introducing bias through the utilization of AI algorithms in PPE design and selection. Such biases could arise from various sources, including historical data sets, human prejudices, or even algorithmic limitations. The presence of such biases could lead to unequal protection for certain worker groups, resulting in unfair treatment and heightened risk of harm.

In addition to this concern, there is also the matter of allocating responsibility and liability in instances where AI-assisted PPE fails to function as intended. In situations where errors are committed by both humans and machines, assigning blameworthiness for damage or loss of life becomes complex.

Lastly, the lack of transparency and accountability in AI decision-making processes can also give rise to ethical dilemmas. It is essential that users have access to information regarding how AI algorithms reach their conclusions, enabling them to evaluate the trustworthiness and fairness of the recommendations presented. This would encourage greater confidence in the technology and its applications.

The WEF highlights some of the key considerations regarding ethical aspects of AI (WEF, 2021). One of the first considerations is inclusiveness. This involves ensuring that everyone, irrespective of their ethnicity, gender, sexual orientation, or other characteristics, has access to the benefits of AI.

AI must be impartial, ensuring that decisions and actions are fair and unbiased to all without discrimination. Developers and users must be accountable for adverse consequences of AI, being transparent about the system's workings. AI requires complete transparency regarding its usage, data. Privacy is crucial in AI development and use, and personal data must be collected ethically and used only for its intended purpose. Security must be respected by protecting the technology from cyber-attacks and ensuring that the data used to train AI is stored and transmitted securely. AI must be sustainable, developed and used in a way that benefits society in the long term while considering its environmental impact.

The Institute of Electrical and Electronics Engineers (IEEE) and United Nations Educational, Scientific and Cultural Organization (UNESCO) have both published sets of ethical principles for the development and deployment of AI systems. The IEEE's "Ethically Aligned Design" document (IEEE, 2019) includes principles such as respecting human rights, prioritizing well-being, and ensuring transparency and accountability. The UNESCO's "Preliminary Study on the Ethics of Artificial Intelligence" (UNESCO, 2019) identifies principles such as respecting human dignity, promoting justice and equity, and protecting privacy and data. Both sets of principles stress the importance of ensuring that AI systems are developed and used in an ethical and responsible manner that benefits society.

## CONCLUSION

The incorporation of AI into PPE represents a substantial opportunity to enhance occupational safety, potentially revolutionizing the way companies approach risk management and hazard mitigation. Nonetheless, it is imperative to address the associated challenges, such as privacy concerns, algorithmic biases, and an overreliance on technology, which could potentially undermine the benefits of this innovation.

To ensure the responsible and effective implementation of AI in PPE, a collaborative approach involving manufacturers, researchers, and various stakeholders is crucial. This cooperation will facilitate the establishment of ethical guidelines, the development of regulatory frameworks, and the identification of best practices for integrating AI into PPE. A balanced perspective is essential in order to objectively assess the potential benefits and drawbacks of AI integration, thereby facilitating informed decision-making and promoting the ultimate goal of creating safer workplaces.

Future research should concentrate on evaluating the long-term effects of AI in PPE, both at the individual and organizational levels, as well as on refining the development and implementation processes. This research must seek to establish best practices that can be universally applied across industries, taking into account the specific needs and characteristics of each sector.

Interdisciplinary collaboration will be essential in order to harness the full potential of AI in enhancing workplace safety. Experts from diverse fields, such as computer science, engineering, industrial and occupational safety, must work together to create comprehensive and robust solutions that address the complex and diverse challenges associated with the application of AI in PPE.

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