RESHAPING THE FUTURE OF PREPRESS WITH ARTIFICIAL INTELLIGENCE

Sandra Dedijer[1][0000-0002-1568-5570], Nemanja Kašiković[1][0000-0002-4416-8070], Živko Pavlović[1][0000-0002-1480-8786], Željko Zeljković[1][0000-0002-6688-107X], Boris Dumnić[1][0000-0002-1846-1986], Aleksandar Anđelković[1][0000-0003-2736-6793], Velibor Premčevski[2][0000-0002-2883-6956]

Abstract

Innovations in artificial intelligence (AI) are shaping the future of almost every industry, and the printing industry is no exception. Applications of AI in the printing industry can be found in prepress optimization, production automation, variable data printing, quality control, predictive maintenance, customer engagement, workflow improvement, and waste reduction. Prepress is the first, crucial and critical stage in the printing process where files are prepared for the actual printing process. It has always been adaptable to changes due to technological requirements and improvements. The introduction of AI in the production phase of prepress has already demonstrated numerous benefits, such as seamless file management, comprehensive preflight checks, advanced PDF editing and automation of repetitive and time-consuming tasks such as file conversion, layout adjustments, trapping and color correction. AI-powered color management systems, which are essential in prepress, are becoming more sophisticated and can predict and compensate for color differences between different substrates and devices. Although the benefits of AI in prepress are obvious, there are still certain challenges and considerations, including the initial investment, data security, complexity of integration and lack of expertise. This paper aims to explore the integration of AI elements in prepress applications and provide a comprehensive overview of the benefits, challenges and future prospects in this area.

Key words: *prepress, artificial intelligence, enhanced efficiency, enhanced quality.*

---

[1] University of Novi Sad, Faculty of Technical Sciences, Serbia, dedijer@uns.ac.rs, knemanja@uns.ac.rs, zivkopvl@uns.ac.rs, zeljkoz@uns.ac.rs, dumnic@uns.ac.rs, aleksa@uns.ac.rs

[2] University of Novi Sad, Technical Faculty „Mihajlo Pupin", Serbia, velibor.premcevski@tfzr.rs

1. Introduction

Printing can be described as a complex process consisting of a combination of graphic technologies that allow graphic elements (drawings, images, text elements, etc.) to be displayed attractively and in high quality on various substrates such as paper, cardboard, fabric, plastic, etc., from a single poster to tens of thousands of copies of a packaging, magazine or book (Liang et al, 2023; Lechene, 2024). The origins of printing lie in history and in wood block printing in China, while in Europe the invention of the wooden press with movable type by Johannes Guttenberg in the 15th century revolutionized book production and provided the unique opportunity to reproduce books in large quantities (Lechene, 2024). We have come a long way from this type of book printing to modernized, technologically extremely complex and advanced large-scale industrial printing processes such as flexographic printing, offset printing, gravure printing, screen printing and personalized, high-quality and fast digital printing. With each of these printing processes, we can print on virtually any type of material and produce graphic products such as books, flyers, posters, newspapers, T-shirts, etc. In the 21st century, advances in printing technology have gone even further, enabling numerous new areas of application, including printed electronics, optics and additive manufacturing.

In all printing processes, the ink is transferred to the substrate using a printing plate, with the exception of digital printing, where the printing plate is omitted. In order to deliver a high-quality printed product, the critical part of the process is the prepress stage, where all the necessary steps are taken to adequately perform plate making or direct digital printing. In this sense, the critical aspects are color proofing and correction, color separation, screening, the RIP process and more (Liang et al, 2023). There is no room for error because today's competitive market demands a high-quality, cost-effective, versatile and fast-delivery print product. Automation of prepress workflows has brought significant advances, but the introduction of artificial intelligence solutions is a real game changer in prepress processes.

1.1 Artificial intelligence and its deployment in graphic industry

Artificial intelligence (AI) refers to a technology that enables a computer or a robot to perform tasks in the same manner as a human, equipped with its characteristic intellectual processes such as the ability to learn, reason, discover meaning, generalize, perceive, use language or learn from past experiences (Tomić et al., 2022; Copeland, 2024). Solutions based on artificial intelligence (AI) are used daily in all printing processes, from prepress and printing to quality control and customer engagement, to ensure higher print quality, cost-effectiveness and efficiency. According to the nature and applicability in graphic processes, these solutions are mostly based on machine learning and vision applications (image processing and machine vision) (Tomić et al., 2022).

AI has opened up an extraordinary opportunity to increase innovation, efficiency and improve results in the graphic arts sector, from designers (automated design suggestions, image enhancement, customized designs) to prepress operations (automated proofreading, color correction, file optimization, trapping), in the printing process (predictive maintenance, quality assurance, optimized ink usage, workflow automation) and in sales (chatbots and virtual assistants, automated follow-ups, efficient quote generation) (Bracamontes, 2023).

Many manufacturers of state-of-the-art digital printing machines for commercial, high-speed and large-format applications are integrating AI solutions alongside cloud and automation technologies to improve color reproduction quality, accuracy, efficiency and profitability (Packaging Europe, 2024). These AI-driven features can automatically determine print settings based on file content, simplify preflight reports and improve image resolution. In addition, AI features help with ink management by predicting ink usage and optimizing inventory levels. They also automate job preparation tasks and, combined with cloud technology, enable remote printing and on-demand production, reducing manual effort and increasing productivity so that operators with different skills can efficiently process different print jobs (Kwality Labels, 2023; Packaging Europe, 2024).

One of the key benefits of artificial intelligence (AI) in the printing industry is its ability to automate repetitive and labor-intensive tasks. AI systems can manage prepress operations such as font identification, color corrections and image scaling, allowing employees to focus on more creative and strategic tasks. In addition, AI-powered software can dynamically analyze and adjust colors in real time, ensuring consistency and optimal print quality. In addition, AI can detect errors during the printing process and independently stop or change processes to minimize them. This automatic quality control reduces both waste and production costs. AI also facilitates the integration of printed materials with digital technologies. For example, when a user scans a printed code or image, AI can trigger an augmented reality experience on their smartphone or tablet, increasing user interactivity and engagement by bringing the printed content to life (Bracamontes, 2023; Kwality Labels, 2023; Gokulnath, 2024).

Graphic design software's manufacturers are incorporating AI in order to provide assistance to designers and others involved in creative industry in generating more visually appealing and market relevant materials, including packaging design, ensuring higher level of functionality and sustainability (Kwality Labels, 2023).

The application of AI in 3D printing is leading to the production of more complex and efficient 3D prints, accelerating the design process, and increasing the accessibility of 3D printing to a broader audience (Kwality Labels, 2023).

2. Harnessing AI for enhanced efficiency and quality in prepress

Prepress is a very important phase in the printing process as it involves the digital preparation of the files to be printed according to the requirements of the printing technology used. It includes all the necessary steps to ensure that the digital files are ready for printing and that the final output meets the desired quality standards: defining the correct format of the files, checking text and graphic elements, managing colour corrections, assigning colour profiles, improving image quality, checking proofs, etc. It is essential that these tasks are carried out properly to ensure the accuracy, consistency and quality of the final printed product. They are sometimes quite repetitive and time-consuming, which affects the overall efficiency of the printing process. The introduction of automation and AI technologies in prepress by streamlining the labour-intensive processes has led to exceptional time and cost management, increased productivity, innovation and creativity, delivering the best results to customers (Bracamontes, 2023; Gokulnath, 2024). Most of the benefits of AI integration in prepress are seen in proofreading, layout adjustments, colour corrections, black generation, file optimisation, trapping, product presentation, better workflow automation, customisation and cloud-based collaboration (Tongkai et al, 2021; Bracamontes, 2023; Gokulnath, 2024).

2.1 Proofreading

AI algorithms can be successfully used for so-called proofreading in the prepress stage to recognise errors in the layout, graphics or text. They are trained to look for unsightly text forms, such as separated words at the end of line breaks, lines that are too long or too short, inappropriate text spacing (line spacing, tracking and kerning), images with insufficient resolution (i.e. less than 300 dpi), etc. (Bracamontes, 2023).

2.2 Colour correction

High-quality printing is characterised by highly accurate colour reproduction, where precise colour management is essential. AI-driven tools and software solutions are of utmost value when it comes to predicting how colours will appear on the substrate and adjusting them in prepress to ensure consistency and accuracy in production. AI-based colour management systems will be even more advanced in the future when it comes to predicting and adjusting colour disparities on different substrates and devices (Bracamontes, 2023; Adroit, 2024).

2.3 File optimization

AI can automatically adjust files for an optimal print format and thus guarantees results of the highest quality (Bracamontes, 2023).

2.3 Trapping

Trapping is a prepress technique used to compensate for registration errors in all printing techniques. It involves creating a slight overlap between neighbouring colour areas to avoid gaps that can occur due to misalignment during the printing process. Trapping is one of the most important processes in prepress as it helps to avoid unnecessary overlaps or problems that could affect registration. AI can help by ensuring precise alignment and minimising the risk of errors (Bracamontes, 2023).

2.4 Incorporating augmented reality (AR) and virtual reality (VR) technologies in printing products

The prepress industry is exploring new frontiers with Augmented Reality (AR) and Virtual Reality (VR) technologies, transforming the way we interact with printed materials. AR enhances tangible proofs by superimposing digital content like videos and animations, making the review process more dynamic and engaging. In marketing, AR adds interactive layers to printed materials, creating a richer consumer experience. VR, on the other hand, offers immersive environments where designers can virtually walk clients through designs, providing a better sense of how they will appear in real life. These advancements are also opening new opportunities in marketing, training, and education (Androit, 2024; Gokulnath, 2024).

2.5 Cloud-based collaboration

Cloud-based collaboration is an emerging trend in the prepress services industry, driven by the need for real-time teamwork. Cloud computing offers numerous benefits, including improved accessibility, enhanced data security, and real-time collaboration. With cloud-based tools, designers, editors, and clients can simultaneously work on the same files from anywhere with an internet connection, resulting in smoother workflows, better communication, and faster project completion. Additionally, features like version control prevent loss of changes or accidental overwriting. Combined with AI technology, it enables prepress technicians and designers to collaborate remotely on projects globally, further boosting its growth (Androit, 2024; Gokulnath, 2024).

2.6 Customization, printing on demand, short-run printing and sustainability

The growing demand for personalized and distinctive items has increased the popularity of personalized printing, pushing prepress services to offer more responsive and flexible solutions. Variable Data Printing (VDP) enables large-scale, high-quality, customizable printing, requiring prepress services to handle complex data sets and ensure seamless digital printing processes. Additionally, on-demand printing is becoming more prominent due to the need for faster turnaround times and reduced inventory costs, driving prepress providers to adopt more agile and

adaptable workflows. Just-in-time printing further minimizes waste and storage expenses by producing materials as needed, necessitating workflow optimization. Short-run printing, a similar trend, allows for smaller print quantities, making it cost-effective and beneficial for small businesses. Finally, sustainability is a growing focus, with manufacturers adopting eco-friendly materials and processes to reduce waste and their carbon footprint (Androit, 2024; Gokulnath, 2024).

3. Use of AI-supported solutions in printing processes: Challenges and opportunities

It is obvious that AI offers a multitude of benefits for the printing process. But we cannot overlook the fact that there are also a number of challenges that we should consider.

Some of the benefits of AI for the printing process are the following:

Increased efficiency and reduced production time, resulting in cost savings and faster turnaround times. In addition, AI has the potential to manage and optimise the entire print production workflow, from prepress to postpress. By automating processes and providing better visibility of performance, AI supports management decision-making and ensures even greater efficiency throughout the production cycle (Kwality Labels, 2023; Sodaal, 2024).

Value creation through print personalisation, where AI can be used to analyse large amounts of customer data and enable a higher level of print personalisation, meeting the growing demand for variable data printing (Kwality Labels, 2023; Sodaal, 2024).

Sustainability by optimising print jobs and minimising errors, which helps to reduce waste. In addition, AI can perform predictive maintenance, which extends the life of printing equipment and reduces the environmental impact associated with the manufacture and disposal of machines. Unlike traditional methods of component replacement, which are based on average operating life, AI can analyse the performance of devices to predict when certain parts will fail. This enables more precise replacement and reduces unnecessary downtime and waste caused by unwarranted component replacement (Kwality Labels, 2023; Sodaal, 2024).

Less repetitive tasks and more creativity through the ability to automate repetitive tasks, allowing employees to focus on more complex and creative aspects of the printing processes. This allows creative professionals to focus on design and innovation, resulting in more imaginative and engaging print materials and allowing operators to focus on higher value-added activities (Kwality Labels, 2023; Sodaal, 2024).

Ensuring high print quality and competitive advantage by analysing the quality of print output in real time, identifying and fixing print quality issues as they arise, thereby reducing waste costs and offering more efficient and cost-effective services that attract more customers and give the company an edge over the competition (Kwality Labels, 2023; Sodaal, 2024).

AI considerations, especially in prepress, are mainly related to the fact that AI tools can occasionally misinterpret the design, so human supervision is still essential. Other challenges include high implementation costs, workforce reorganisation and data security (Bracamontes, 2023; Kwality Labels, 2023).

4. Conclusions

Technological development in the printing industry is far-reaching, with artificial intelligence (AI) being the latest transformative development to augment human expertise. The integration of AI has led to advances in automation, personalisation, optimisation, sustainability, productivity and cost efficiency, while enabling data-driven decision-making. This shift allows professionals to focus more on creativity and innovation and deliver better results to clients while saving costs and time. Although challenges such as implementation costs and workforce adaptation remain, the potential for growth and innovation is significant. With increasing access to AI-driven solutions, the print industry is poised for a major transformation that will revolutionise design, production and marketing. The synergy between AI and print promises a future of greater efficiency, customisation and competitiveness, with the full potential of AI yet to be realised.

Acknowledgments

REFERENCES

[1] Adroit, S. (Jun 28, 2024). *Future Trends in Prepress Services: What to Expect in the Next Decade.* Medium blog.
[2] Bracamontes, J. (2023). *How is AI Affecting the Print Industry?* PryntBase. https://pryntbase.com/how-is-ai-affecting-the-print-industry/
[3] Copeland, B.J. (2024). *Artificial intelligence.* Encyclopedia Britannica. https://www.britannica.com/technology/artificial-intelligence
[4] Gokulnath, B. (2024). *The Future of Prepress: Emerging Trends and Technologies Reshaping the Industry in 2024!* HurixDigital. https://www.hurix.com/the-future-of-prepress-emerging-trends-and-technologies-reshaping-the-industry/
[5] Kwality Labels (2023). *How AI is Changing the Printing Industry.* https://www.linkedin.com/pulse/how-ai-changing-printing-industry-kwality-offset-printers-nhzvf
[6] Lechene, R. (2024). *Printing.* Encyclopedia Britannica. https://www.britannica.com/topic/printing-publishing

[7] Liang, J., Zhang, Z., Wang, H., Zhang, W. & Mo, L. (2023). Graphic Technology in the Digital Age: Fostering creative talents for the future of printing. In A. Politis, M.Tsigonias & G. Gamprellis (Eds.), *Proceedings of the 54th Annual Scientific Conference of the International Circle Circle of Educational Institutes of Graphic-Media Technology and Management* (pp. 106–112). International Circle of Educational Institutes of Graphic-Media Technology and Management. https://www.internationalcircle.net/wp-content/uploads/2023/11/IC-Proceedings2023.pdf#page=105

[8] Packaging Europe (2024). *Fiery to harness AI, cloud, and automated digital print technologies at drupe.* Packaging Europe. https://packagingeurope.com/news/fiery-to-harness-ai-cloud-and-automated-digital-print-technologies-at-drupa/11336.article

[9] Sondaal, S. (2024). *Five ways AI transforms print production.* Label and Narrow Web. https://www.labelandnarrowweb.com/contents/view_experts-opinion/2024-02-05/ five-ways-ai-transforms-print-production/

[10] Tomić, I., Pinćjer, I., Miketić, N. & Adamović, S. (2022). Artificial intelligence in printing. In G. Vladić (Ed.), *Proceedings – The Eleventh International Symposium GRID 2022* (pp. 453- 458). University Of Novi Sad, Faculty Of Technical Sciences, Department Of Graphic Engineering And Design. https://doi.org/10.24867/GRID-2022-p49

[11] Tongkai, X., Manjiang, L., Shanmin, L., Jiliang, X. & Zhende, Y. (2021). When Artificial Intelligence Meets Printing the Evidence of Black Generation. *EAI Endorsed Transactions on Scalable Information Systems, 8*(33), 1–5. http://dx.doi.org/10.4108/eai.29-10-2021.171686