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Embracing integrated tech in graphic communications: Industry 5.0 perspectives

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Abstract

This study provides a holistic overview of integrated technologies, covering examples such as automation, artificial intelligence (AI), the internet of things (IoT), big data (BD), machine learning (ML), and extended reality (XR) and their applications within the graphic communications industry. By leveraging a systematic literature review utilizing both quantitative and qualitative publications, this study aims to answer the following question: "*In the graphic communications industry, do the implementations of integrated technologies have an impact on the quality of performance of organizations and the users who have adopted them in the previous 10 years*?". Identified publications are selected in order to contain a variety of different perspectives from a multitude of authors to make it clear that new approaches containing unprecedented use of integrated technologies are bringing continuous development and change, both positive and negative. They will reshape our current approach to technology in the graphic communications industry and will therefore transform the way lives are lived. A pilot study was conducted by Syeda and El Asaleh in 2022 about the integrated technologies available in the graphic communications industry. This study expands on previously existing research, now encompassing a more in-depth analysis to continue to shed light on existing implementation. These new opportunities and existing limitations will aid in determining the path the future of the graphic communications industry will take in the revolution of Industry 5.0. This paper is part of ongoing research at The Creative School of Toronto Metropolitan University (Formerly known as Ryerson). It will serve as a basis on which further research will be conducted, as the topic is one that is often neglected and overlooked within the field of graphic communications.

Keywords: artificial intelligence, automation, integrated technology, graphic communication, Industry 5.0, human capital

1. Introduction and background

Automation, artificial intelligence (AI), the internet of things (IoT), big data (BD), machine learning (ML) and extended reality (XR) that includes augmented reality (AR), virtual reality (VR) and mixed reality (MR), are more than modern terms. These technologies have created new potential innovations within the workplace, and it has been ruling many aspects of our daily life. automation essentially substitutes mundane or physically challenging labor by limiting human involvement. This technological-industrial integration has been, once again, revolutionizing our means of production and increasing productivity as never before. Businesses and economies worldwide are benefitting from this integration into their workplaces. The results are not immediate, but the long-term benefits are significant for companies. McKinsey (2019) stated that "the automation of activities can enable businesses to improve performance by reducing errors, improving quality and speed, and in some cases achieving outcomes that go beyond human capabilities". For instance, VIZIT, a packaging mockup tool, provides a practical demonstration for consumers looking for a front-back-end automated solution. By delivering virtual prototypes for packaging design visualizations, VIZIT enables users to customize, personalize and view their mockup in real-time, limiting the need for human involvement in mundane tasks (VIZIT, 2022).

Industry 4.0 is here and it is growing, however, it also brings certain concerns for the general population. The substitution of workplace labor by machines has unshackled workers to focus on higher-value tasks or establish new ones, which leaves an uncertain future scenario for the availability of work. Many employees fear that there will not be enough jobs with the increasing integration of automation and artificial intelligence in the workplace or that some jobs will become obsolete. Seeking this, many individuals are already looking forward to the fifth industrial revolution. Nahavandi (2019) defines Industry 5.0 to be an environment "where robots are intertwined with the human brain and work as collaborators instead of competitors". Increased efficiency and intelligent systems are combined with human labor, which comes back to the fold 10 times over, to create revolutionary machinery in Industry 5.0. This research study will go deeper into the transition between Industry 4.0 and Industry 5.0, examining the challenges and opportunities that these technologies present to businesses in the graphic communications industry, and will, more specifically, discuss whether Industry 5.0 will see a balance of collaborative robots (cobots), and the impact of them.

This paper will provide background information about promising technologies that are already taking place in the industry nowadays and discuss their use within Industry 5.0, a new production model that emerges as a favorable alternative for the future of our society. The findings and analysis will showcase that although these technologies offer a reprieve from day-to-day mundane tasks, they will not be commandeering human labor, but rather offering an alternative to allow human talent to focus on higher order thinking skills. A systematic literature review was employed in order to construct a base from different authors and their perspectives to draw conclusions based on the evidence presented. The paper utilizes a systematic review to critically evaluate relevant literature and focus on contemporary applications in various graphic communication industry sectors such as graphic arts, graphic design, packaging, printing, and others. This information will benefit those within the graphic communications industries and those who are considering the implementation of integrated technologies within their respective businesses. It will explore the numerous benefits and drawbacks associated with the usage of integrated technologies, as well as their impact within the graphic communications industry, focusing on performance quality and user experience.

Given the scarcity of existing research on the subject, this study is especially important because it expands on previous research that was the first of its nature, thereby contributing to further research in this field. It provides a systematic review with clear definitions of emerging technologies such as AI, IoT, BD, ML, XR, and automation, as well as demonstrates a holistic approach to discussing the implementation of integrated technologies in the graphic communications industries, thereby making available evidence more accessible and advancing the research conducted within the graphic communications industry.

1.1 Back-end and front-end interrelation

Technologies in the current industry are diverse, from AI to IoT, and they all connect to each other in the automated production process, as seen in Figure 1. In many cases, they are not all employed at the same time, yet this whole process and the information flow are leveraged by automation as it continuously improves over time. Artificial intelligence enables the workflow to evolve as long as it learns, depending less on humans and manual programming to perform daily tasks in the production process. As technology continues to evolve rapidly, the merger of robotics and the human mind is causing huge breakthroughs in AI, which will play a machine-independent role in Industry 5.0 allowing for a collective synergy between humans and autonomous machines.

1.2 Definitions

1.2.1 Automation

The integration of automation has been found to significantly contribute to productivity, thereby driving economic growth and prosperity of businesses (PR Newswire, 2019). This is particularly evident in industries that rely heavily on data or require low-skill labor. According to a study by McKinsey (2019) the combined activities of manufacturing, accommodation and food services, and retail trade significantly contribute to the US economy, accounting for over half of its economic output and generating nearly $2.7 trillion in wages. It is noteworthy that this data encompasses both average and high-income earning careers, not just low-wage occupations. In light of these findings, this study aims to demonstrate the relevance of

Figure 1: Information process of back-end & front-end integrated technologies

auto-mation technology in the graphic communications industry.

The introduction of automation is not a new concept, as it was already introduced during the mid-20th century with the advent of industrial robotics in the third industrial revolution. However, automation has evolved significantly since then, with cutting-edge AI technologies enabling Industry 4.0 to create smart robots capable of self-learning and functioning autonomously, in contrast to the highly-controlled environments of Industry 3.0 robots (Tantawi, Sokolov and Tantawi, 2019). The goal of automation is to substitute mundane or physically difficult labor, while also complementing human labor by performing tasks that machines cannot complete. It is important to note that workers who supply tasks that automation complements are more likely to benefit from automation than those who supply tasks that machines can complete individually (Muro, Maxim and Whiton, 2019). The combination of robots and the human mind is leading to massive advancements in AI, which will play a machine-independent role in Industry 5.0.

1.2.2 Artificial intelligence

Artificial intelligence is a multifaceted concept that can be defined in various ways based on different categories of intelligence. Abbass (2019) provides a simple definition of AI as the design of algorithms to enable computers to possess cognitive skills and competencies for sense-making and decision-making. This highlights the ability of AI to utilize machine cognition to perform tasks. Over the past decade, AI has benefited from advancements in sensor technology, communication, the Internet, computer speed, and storage (Abbass, 2019; Zhang and Lu, 2021). AI systems are capable of performing specialized functions that are widely used in numerous industries today. For instance, Microsoft's humanoid robot, Sophia, has human-like capabilities that enable her to perform a range of tasks. Her anthropomorphic abilities demonstrate how AI has become critical in various industries. Artificial intelligence is an excellent example of biomimicry, which involves transferring analogs from the biological field to technology (Vincent, et al., 2006).

The way AI operates is inspired by the human brain's process of learning through pattern recognition and data analysis. Machine learning and neural networks, which are also examples of biomimicry, explain how AI systems process data and acquire knowledge. Other notable examples of artificial intelligence include self-driving cars, kiosks, and widely used virtual assistants, such as Amazon's Alexa, Apple's Siri, Google's Home Assistant, or Snapchat's Chatbot (De Silva and Alahakoon, 2022).

1.2.3 Internet of things

IoT is a revolutionary concept that has changed the way data is collected and transmitted for various industries. Patel and Patel (2016) define IoT as the interconnection of all sources of data over public or private internet, protocols and networks, allowing for a vast amount of data to be collected and transmitted at high speeds. This concept involves the pervasive presence of various objects in the environment that can interact with each other through wireless and wired connections, creating new applications and services. IoT captures a large amount of data from connected devices that are mostly unanalyzed. Technologies such as cloud computing, near field communications (NFC), intelligent sensing, radio-frequency identification (RFID) tags, and wireless sensor networks (WSN) are some of the tools that contribute to IoT. These technologies either employ tracking and collecting data or provide a platform and tools to analyze it (Li, Xu and Zhao, 2015). The integration of AI with IoT has revolutionized the way data is collected, transmitted, and analyzed, leading to more effective decision-making processes.

The internet of the things has become ubiquitous across a wide range of industries, including healthcare, the food industry, supply chain management, manufacturing, and more. Additionally, personal applications such as wearable devices have leveraged IoT to monitor fitness progress or human health issues and provide valuable accessibility solutions. Researchers such as Domingo (2012), Jara, Zamora-Izquierdo and Skarmeta (2011), and Bandyopadhyay and Sen (2011) have provided numerous examples of successful IoT implementations in various industries. Li , Xu and Zhao (2015) also provided a comprehensive summary of IoT implementation across several industries, while Bi, Xu and Wang (2014) focused on the implementation of IoT in modern manufacturing enterprise systems. In the field of graphic communications, IoT is heavily utilized in enhancing customer engagement and marketing applications (Albrecht, 2018; Bergman and Johansson, 2017; Tambo and Lydekaityte, 2019). The integration of AI with IoT has further facilitated the collection, transmission, and analysis of data in these industries, aiding in efficient procedures and processes.

1.2.4 Big data

According to definitions provided by Zheng, Zhu and Lyu (2013) and Beyer and Laney (2012), BD refers to information assets that are high volume, high velocity, and high variety. In order to enable enhanced decision-making, insight discovery, and process optimization, new forms of processing are required. The 21st century has marked the start of the fourth industrial revolution, which has seen an increased adaptation of automation, cloud computing, smart technology, and other service technology. This has led to an explosion in data generation by these services and other mobile devices, IoT applications, social networks, and more. As a result, the integration of AI with IoT has become crucial in facilitating the collection, transmission, and analysis of data in these industries, ultimately leading to more efficient and effective decision-making processes.In order to handle the large amounts of data generated, it is essential to employ secure storage systems such as cloud storage (Nahavandi, 2019).

To ensure efficient data analysis, it is necessary to pre-process the information and filter out irrelevant data before AI algorithms can learn and analyze it. Data modeling and analysis techniques are also important in identifying patterns and correlations within datasets that can provide insights into potential trends or solutions. The use of ML technology depends heavily on the accuracy and quality of the collected data, which can be leveraged to enhance decision-making processes, improve quality control, and evaluate performance (Junjun, 2021; Wei and Xiangbo, 2020; Knoll, et al., 2019).

These scientific approaches are crucial in making sense of the vast amounts of data generated by modern technologies and can help drive innovation and progress in various industries.

1.2.5 Machine learning

Machine learning is a rapidly evolving branch of computational algorithms that aims to emulate human intelligence by learning from the surrounding environment (El Naqa and Murphy, 2015).

Machine learning enables the perception of hidden information without being explicitly programmed to do so, which can lead to valuable insights and improvements in various industries. Different models of ML are designed and implemented for specific purposes, such as the use of convolutional neural networks in the graphic arts industry to prioritize complex analyses of visual data. There are many techniques and methods of ML, but they can generally be divided into two distinct groups: traditional learning and deep learning. Traditional learning is limited to completing tasks it was designed to do, while deep learning allows AI systems to learn complex patterns from large data sets to inform future optimizations.

1.2.6 Extended reality

Extended reality serves as an encompassing term for a spectrum of technologies that dissolve the boundaries between the physical and digital environments. By integrating digital elements into the real-world environment, XR crafts an immersive and interactive experience for users. This expansive field encompasses AR, VR and MR, each offering unique ways to blend realities. In the realm of graphic communications, XR technologies are sparking a revolution in how visual content is not only created but also experienced and shared. These innovations extend across various applications, spanning from design visualization and virtual prototyping to immersive brand experiences, interactive marketing campaigns, and beyond, reshaping the landscape of visual communication (Chuah, 2019; DeSouza, 2021; Dwivedi, et al., 2022, 2023; Liu and Nhung, 2022; Ramírez-Durán, Berges and Illarramendi, 2021).

Augmented reality

Augmented reality integrates computer-generated elements, such as images, videos, or 3D models, with the user's view of the physical world, typically through a camera-enabled device like a smartphone or AR glasses. By superimposing virtual information onto the real world, AR enhances the user's sensory experience, providing additional context, information, or interactive elements. AR can be used in various domains such as graphic communications, gaming, education, training, marketing, and industrial applications, offering immersive and interactive experiences that bridge the gap between the physical and digital realms. A popular example of AI in the twentieth century was the viral mobile game Poke (Bhat et al., 2019; Eswaran & Bahubalendruni, 2022).

Virtual reality

Virtual reality is a technology that creates a simulated, computer-generated environment, typically experienced through a head-mounted display or VR goggles (Zhang, et al., 2020). VR aims to immerse users in a virtual world that can be entirely fictional or based on real-world environments. By replacing the user’s sensory input with the virtual environment, VR offers a highly immersive experience where users can interact with and explore the digital world. VR technology tracks the user’s movements, adjusting the displayed visuals and audio accordingly, creating a sense of presence and realism (Balzerkiewitz and Stechert, 2021; Ke, et al., 2019). VR finds applications in various fields, including graphic communications, gaming, entertainment, education, simulations, architecture, and training, providing users with a compelling and interactive experience that transports them to a different reality. (Dwivedi, et al., 2023; Herz and Rauschnabel, 2019; Zhang, et al., 2020).

Mixed reality

Mixed reality, often referred to as hybrid reality, represents a convergence of AR and VR technologies, blending digital elements seamlessly with the real world. In the MR realm, digital entities interplay with and respond to the physical environment, enabling users to interact with virtual objects while maintaining a clear awareness of their surroundings. Just like its AR and VR counterparts, MR finds applications across diverse domains like gaming, education, healthcare, sports, retail, and beyond (Ke, et al., 2019; Ramírez-Durán, Berges and Illarramendi, 2021; Sung, et al., 2021). A standout exemplar of MR in action is the widely popular mobile game Pokémon Go, which ingeniously merges digital creatures with real-world settings, captivating millions through its immersive and interactive experience.

1.3 Industry 4.0 vs. Industry 5.0

Throughout history, there have been four significant industrial revolutions that have marked a shift in the way we produce goods. The first revolution saw the utilization of water, steam, and fossil fuels as mechanical power. This revolution introduced the factory system, which allowed for the organization of work in specialized functions, and the transition from handcraft to machine fabrication, which allowed for increased productivity and consumption. The second revolution, which began in the 1870s, saw the introduction of assembly lines, mass production, and the utilization of electrical energy by manufacturers (Mokyr and Strotz, 2000). The third revolution was characterized by advancements in electronics, telecommunications, and computers (iED, 2019). The employment of robots in the production process enabled high-level automation. The fourth revolution, commonly referred to as Industry 4.0, is marked by the integration of cyber-physical systems (CPS), cloud computing, and the internet of things. This integration has improved computerization and automation started in the third revolution. The benefits of this digitalization include the “enhancement of operational efficiency, improved responsiveness, boosted traceability, strengthened capacity utilization and reduction in costs” (Rossini, et al., 2019, as cited Chauhan , Singh and Luthra, 2021). Despite some scepticism regarding the validity of the fourth revolution, it is clear that countries and their levels of technological development affect the industrial modes of production, making it difficult to define globally (Garrido-Hidalgo, et al., 2019; Marr, 2018).

However, it is beyond doubt that numerous industry sectors are open and adapting to new technologies, trusting their potential. A Grand View Research report revealed that the global AI market was valued at 63 billion dollars in 2021, and it is expected to grow to almost a trillion USD by 2028. In 2022, most of its market share (over 36 %) was concentrated in North America, and software solutions accounted for more than 38 % share of the global revenue (Precedence Research, 2023). Big companies such as Microsoft and Apple are heavily investing in AI technologies, whether forming partnerships or acquiring AI-specialized firms (ReportLinker, 2021). Moreover, beyond the tech market, the impact of Industry 4.0 is perceived in many other sectors. The packaging industry, for example, has used AI for activities such as sorting recycling goods, date labelling, inspections, shipping, and warehouse automation. Case studies revealed that implementing automation in this sector resulted in an excellent return on investment (ROI) (Significans Automation, 2021). Also, because of technological advancements, smart packaging has emerged, offering innovative solutions for many manufacturers and new business opportunities (Schaefer and Cheung, 2018). Machine innovation can lead to product innovation as technologies could be able to reach results humans could not (Demir, Döven and Sezen, 2019).

Although concerns from the public about the rapid pace of technological advancements in Industry 4.0 are valid, the fear of an AI takeover or a dystopian future in which humans become extinct is unfounded. The primary concern is the impact on employment, as the gig economy is causing workers to experience growing informality, with companies eliminating the minimum wage, healthcare, and other benefits guaranteed by employment laws. However, Stanford (2020) argues that the direction of change is ultimately determined by conscious and collective decisions made by society, rather than technology alone. It is also important to consider sustainability, ethics, and politics as potential drawbacks of Industry 4.0. Assessing the impact of the gig economy or Industry 4.0 on employment is complex, and if job numbers stagnate or decrease, the benefits of the fourth industrial revolution may be nullified, leading to political leaders being pressured for results (Calış Duman and Akdemir, 2021; Margherita & Braccini, 2021; Nahavandi, 2019; Demir, Döven and Sezen, 2019; Ramírez-Durán, Berges and Illarramendi, 2021; Xu, et al., 2021).

As a response to these concerns, some experts have begun looking towards the fifth industrial revolution. Martynov, Shavaleeva and Zaytseva (2019) suggest that Industry 5.0 will involve humans working alongside machines to increase process efficiency while also prioritizing human well-being and the greater good. Nahavandi (2019) defines Industry 5.0 as the pairing of “human and machine to further utilize human brainpower and creativity to increase process efficiency by combining workflows with intelligent systems”. The main drivers behind Industry 5.0 are mass customization and optimistic forecasts regarding technological progress. Here are four of Industry 5.0 main points:

- Cobots. Collaborative robots will have a key role in Industry 5.0. According to Pizoń, et al. (2022), they facilitate human–robot collaboration, enhancing productivity and cooperation through advanced ML, autonomous decision-making, and state-of-the-art AI and sensing technologies.

- Value-added production process and jobs. Industry 5.0 will require highly skilled specialists, including a predicted "Chief Robotics Officer" (CRO) with expertise in human–machine interaction to optimize efficiency and performance. Unique human abilities will be valued with significant and well–paid jobs on factory floors and in creative roles (Nahavandi, 2019).

- Human-centered. Industry 5.0 focuses on human-centred approaches to address the scarcity of employment opportunities, particularly in low and lower-middle-income countries with high population growth rates. Cobots handle repetitive and complex tasks, allowing humans to engage in creative and intellectual activities, fostering satisfaction and collaboration (Abeliansky, et al., 2020; Nahavandi, 2019).

- Mass customization. Industry manufacturing will be shaped by consumption tendencies as people seek more personalized and exclusive products. Companies must adapt and employ technologies that can cater to these demands, integrating the human touch and creativity with skilled robots. This will enable the production of cutting-edge, high-quality personalized goods, from mass production to mass customization (Østergaard, 2020).

In order to understand the main differences between Industry 5.0 and the fourth industrial revolution, it is crucial to examine the role of humans in the industrial scenario. While Industry 4.0 sought to automate and replace workers, Industry 5.0 will take a different approach by bringing humans back into the equation to collaborate with robots. Additionally, Industry 5.0 will prioritize important questions for the future, such as sustainability and finding a balance between production and efficiency. According to Martynov, Shavaleeva and Zaytseva (2019), Industry 5.0 will integrate physical and virtual space to solve not only production problems, but also social problems. Meanwhile, Østergaard (2020) views Industry 5.0 as a new era of goods production that is enabled by the most advanced industrial automation technologies available.

Another way to comprehend this evolution is by looking at what the industry is producing and what it could produce within the fifth industrial revolution. The publishing industry, for example, has been benefiting from automation since the 1970s (Amnet, 2018). Processes like authoring, editing, multimedia infusion, book design and stylesheet, artwork, final proof, and others (Impelsys, 2018) can take advantage of automated workflows in order to increase productivity in less time and reduce costs. Over time, the publishing industry had to adapt to the digitization phenomena and started delivering multiple different products and formats (e.g., XML, PDF, ePUB), besides common printing. This seems to be a tendency: even though e-readers will become more and more popular, well printed books will still be carried around and many more products will also become part of the publishing industry scope. This variety of products is key to what Industry 5.0 could contribute in the near future. Technologies such as AI, could meta-tag images to digital publishing formats, convert print book layouts into ePUBs layouts, and help gather data from eBook readings in order to create statistics, beyond many other possibilities empowered by digitization. Mass customization enabled by Industry 5.0 will also be an important and innovative step to be taken into this industry sector, enabling readers to connect in a new way to published media. Employees could then focus on creative forms of achieving these possibilities, adding important value to the production process.

Digital Asset Management (DAM) systems provide businesses with the opportunity to centralize storage and streamline design processes and access to all formats of assets, including images, videos, audio files, and documents. DAM has the ability to enhance collaboration and allow numerous teams to efficiently handle digital creatives in a central location, which makes it another sector of the graphic communications industry where workflow automation has played a prevalent role. DAM systems like Aprimo (Barber, 2022) and Bynder (n.d.) offer centralized asset management, facilitating collaboration and ensuring asset consistency. Combined with AI and digitization allows these DAM tools to revolutionize industries by auto-tagging, helping with image recognition, enabling automated workflows, personalized content, and improved user engagement.

The COVID-19 pandemic has evidenced the need for a radical change in the way we produce and consume. For manufacturers, new technologies have proven to be an essential investment, as they have been providing great solutions that are keeping the industry on track. Social distancing has been facilitated by remote access technologies, part of a new normal that is transforming many companies and their workflows.

Big data can be used in favor of businesses and their operations, helping to safely predict scenarios in uncertain times. According to Gamota (2020), the coronavirus pandemic has pushed people to learn new technologies and troubleshoot their problems, counting less on external help. The virtual age heralded by the pandemic (Mehendale and Radin, 2020 cited in Gamota, 2020) is leading the industry to the path of the fifth industrial revolution, which will require human adaptability to work collaboratively with machines. Human creativity, innovation and critical thinking alongside smart technologies are at the core of Industry 5.0.

Generative AI is revolutionizing the graphic communications industry, offering innovative design, production, and workflow optimization solutions. AI-powered tools automate tasks like image editing, content generation, and font matching, enhancing designers' creative process efficiency. AR integration via QR codes in print advertisements provides interactive experiences. VIZIT Packaging Mockups and Adobe Sensei's automation technologies facilitate virtual prototypes, real-time visualization, customization, and collaboration, reducing costs and waste (VIZIT, 2022). AI-driven web-to-print platforms automate file analysis, dynamic templates, image enhancement, and product recommendations, improving efficiency and customer experience. Imposition software like Tilia Labs Inc.' Phoenix AI and Ultimate Impostrip optimize imposition through AI algorithms, reducing time and increasing productivity (Tilia Phoenix 7.0 Tilia Labs Inc., 2019). Chili Publish is known for its powerful online document editing solution, and while it also offers imposition capabilities, its main focus lies in automation and integration with AI-driven tools in the graphic communications workflow (Chili Publish, 2020). As generative AI evolves in the graphic communications industry, these examples showcase its potential to transform design workflows, personalized experiences, and production processes.

2. Materials and methods

A systematic literature review was conducted based on PICO (Population, Intervention, Comparison, and Outcome) guidelines to showcase background information and current implementations of promising integrated technologies already taking place in the industry and discuss their use and challenges within Industry 5.0. The study was considered to showcase the benefits and drawbacks of the implementation of relevant integrated technologies, such as automation, AI, IoT, XR, BD, and ML. The current challenges faced, barriers, and the road to Industry 5.0 are also discussed.

The study pulls over 499 academic papers, from theses to conference publications, to research reports. The available literature was gathered from sources, such as the Toronto Metropolitan Library, Web of Science, ScienceDirect, Communication & Mass Media, Google Scholar, and the OpenDOAR database. The team took five main steps as we aimed to gather all empirical data that fit our pre-specified criteria to answer the research question posed.

The first step was to identify and frame the research question using the PICO method to strategize the population, intervention, comparison, and outcome thereby developing the appropriate search strategies.

The second step was to define the inclusion and exclusion criteria, allowing the team to focus on the keywords that would be used throughout the literature search.

The third step was to manually filter and extract data from the aforementioned resources.

The fourth step was to select studies that fit our inclusion criteria. Using the keyword database created, the team used the boolean logic technique of using both and/or to track down literature. The secondary screening was followed for final inclusion in the review, determining if the studies met the pre-determined criteria, and thereby limiting any biases ensuring the systematic review was approached with a holistic view.

The final step was data extraction from the selected studies to report findings and conclusions. Any disagreements were discussed openly allowing the team to assess and compromise on all matters.

The overarching themes were organized into a coherent framework, drawing from a holistic analysis of various sources. This process involved identifying key challenges, summarizing the outcomes of conducted tests, and thoroughly examining findings concerning the initial research question. Moreover, acknowledgments were made to observe any limitations encountered. To further streamline the approach, the research question was deconstructed into four distinct verticals, categorizing group-related elements from previous works. The initial categorization not only streamlined the process but also unveiled commonalities and distinctions within the existing framework, encompassing process optimization, quality control, decision-making, and user satisfaction. As common themes surfaced from the articles within these categories, they naturally gave rise to complementary sub-categories like Creativity, Production, and Management, corresponding with the fundamental categories of process optimization, quality control, decision-making, and user satisfaction. Notably, our investigation highlighted similarities across the articles, and individual findings were not siloed but involved referencing the analogous similarities. For example, individual papers may have similarities, such as ethical concerns with AI (Omrani et al., 2022), the initial implications of human–machine integration (Prassida AND Asfari, 2022), or the impact of the efficiency of cost and materials (Wang, et al., 2020) that were present in other studies. By leveraging these shared characteristics, the body of the paper was skillfully constructed.

While this approach is not a unique research method technique, the singularity of this study is that it is one of the only available studies that cover the wide scope of sectors in the graphic communications field and hence bridges a research gap that was previously present. The findings that have been analyzed will benefit those within the graphic communications industries as well as those who may be thinking about integrating these technologies within their businesses and are focused on performance quality and customer interactions. The exploration of the many benefits and drawbacks associated with the implementation of integrated technologies within a workplace setting allows a basis for professionals in the industry to consider the use of these promising technologies, and how it may impact their company's process optimization, quality control, decision making, user satisfaction, creativity, production, and management.

3. Results

The figures 2 - 4 showcase the raw data that was used from the second screening throughout the systematic literature review process. This visualization serves to provide insights into where these papers are sourced from and when they were produced.

The article distribution analysis in Figure 2 shows that most articles are concentrated in North America, Europe, and Asia. There is a scarcity of sources that root back to Africa and the Middle East, however understanding that Industry 5.0 is within near-reach, the aim is to see increased efforts in these areas. Apart from the three categories presented in Figure 3, a multitude of other sources were also included within the systematic literature review, including Theses', peer-reviewed articles, government papers, and university textbook chapters. The three emerged as the dominant categories, as they proved particularly valuable showcasing quantifiable data, and testing methodologies. Papers were analyzed from 2011 onwards, however, the Figure 4 includes papers from post 2014, to ensure the information showcased aligns with the ever-growing and rapidly evolving nature of the industry. Notably, the majority of the selected articles were published in recent years, with 2021 exhibiting the highest collection rate.

With a grasp of the informational sources that have contributed to the systematic literature review, there are also worries that emerged with Industry 4.0 and past industrial revolutions, which are now being embraced by Industry 5.0 solutions. Unfortunately, and inevitably, others remain and new ones appear. Industry 5.0 certainly has good premises, but it is important to understand its limitations and all the parts involved in the process to make it what it is expected to be in the future. Big tech companies, technology fair access, and ethical questions are examples of important subjects to be addressed in order to prepare a safe path to the next industrial revolution.

A question that was already brought up by the fourth industrial revolution: who would benefit the most from industrial technology innovations? The answer seems easy: larger companies have always been ahead

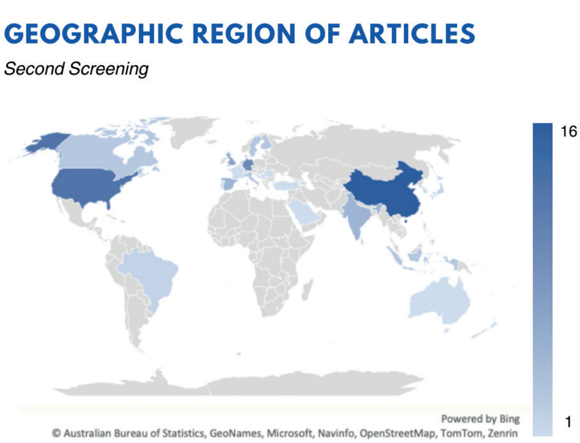

Figure 2: Representation of the sources from the second screening categorized by geographic region.

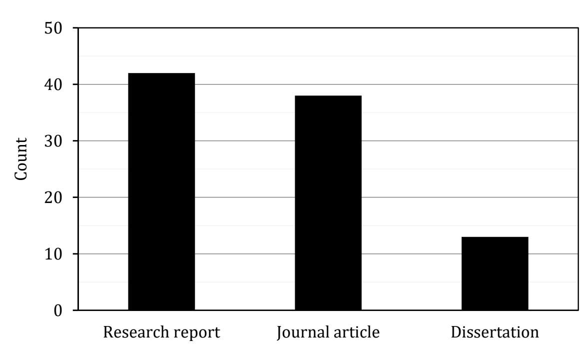

Figure 3: Dominant categories of sources from the second screening based on publication type.

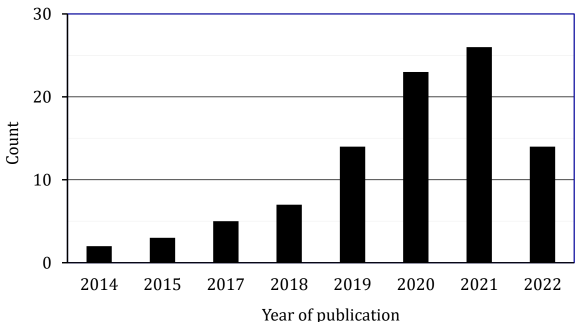

Figure 4: Representation of the papers collected in the second screening based on the year of publication.

when it comes to new technologies employment. Even though these are expected to become more accessible through time and development, they must be guaranteed to keep a fair market share among different businesses. Industry tech owners must make an effort to provide solutions for small firms. There are already semi-automated systems (in contrast to the larger full ones) available in the market that could be adopted by small-scale businesses. According to Moore's Law, electronic devices tend to get smaller over time, which could contribute to the growth of new tech employment by small-scale firms.

New technologies should also be seen through the ethics lens, in order to identify the implications that come along. AI bias, for example, is one major problem that has been drawing a lot of attention recently, resulting in many studies by researchers and technologists (Kumpulainen and Terziyan, 2022; Margherita and Braccini, 2021). Therefore AI bias must be taken into consideration to ensure that algorithms work in favor of all humans in all conditions, promoting the harmonic collaborative workforce expected. Generative AI can be difficult to accept as it provides a limited explanation when formulating a result (Epstein et al., 2022; Omrani et al., 2022). As long as these integrated technologies like Tilia Labs Inc.' Phoenix AI, Chili publish, and Adobe Sensei are fed ethical data and correct criteria, companies can generate respectable outputs.

The most important question is: would machines replace humans, would the increased adaptation and integration to those emerging technologies replace the human factor and expertise? Several studies were focused on exploring human–machine interactions (Abbas, 2019; Albrecht, 2018; Nahavandi, 2019), while others concluded that while using emerging technologies would provide real-time solutions and enhance the decision-making process, the need to have human involvement and expertise is an asset (Calış Duman and Akdemir, 2021; Verganti, Vendraminelli and Iansiti, 2020; Doehling, 2019; Dwivedi et al., 2023; Ramírez-Durán, Berges and Illarramendi, 2021; Zhang and Lu, 2021). With programming tools like Adobe Firefly that provide a generative AI solution, Tilia Labs Inc., and Chili publish, there is a tendency in society to associate these technologies in the workplace with negative consequences (Computer Express, 2023). The fear and uncertainty of these technologies have led to a reluctance to learn about the potential these mechanisms can offer to the workplace (Kinkel, Baumgartner and Cherubini, 2022; Luthra, et al., 2018; Margherita and Braccini, 2021; Trepanier, 2023; Westenberger, Schuler and Schlegel, 2022; Zerilli, Bhatt and Weller, 2022). Understanding that industries driven by creativity, such as the graphic communication sector, are subjective and dependent on catering to the needs of a consumer, human involvement remains a necessity. AI's role is not to substitute human labor but rather to foster opportunities for human participation to engage in higher-order thinking activities, such as supervising and project managing client expectations to deliver the most effective creative solutions. (Barredo Arrieta, et al., 2020; Botvinick, 2022; Makridakis, 2017).

The final question is: will there be smart enough technologies available in the next future? Cobots and the idea of a perfect collaborative synergy between machines and humans will require a high level of automation and tech advancements never seen before. Industry 5.0 intentions are likely to be achieved, however, they rely on technological progress that requires time and investment. At the present moment, technology has been providing incredible contributions to industrial automation this ultra-connected environment is a significant step toward integrating humans with machines. AI, ML, big data, IoT, and many others are the beginning of the future for the next industrial revolution.

4. Discussions

Linking to the research question when exploring the impact of implementing the integrated technology on the overall quality of performance of organizations and how that was also reflected in users who adopted them, articles in this study were subcategorized into three categories (Figure 5) that mainly reflect the graphic communications workflow which usually starts from ideation (i.e. graphic design, packaging design, creativity, etc.) through the actual production process which is also aligned with management and finally, records customer satisfaction of the service or the products. These subcategories were created by streamlining larger terminologies such as process ptimization, quality control, decision making, and User Satisfaction. These categories examine the overall representation of back-end to front-end processes within graphic arts.

4.1 Creativity

The graphics arts industry relies heavily on creativity, which involves various processes and workflows. However, with the emergence of immersive technologies such as AI, IoT, XR, and BD, creative professionals can now benefit from unprecedented levels of assistance in their craft. This subcategory of articles explores how integrated technologies are transforming traditional creative professions such as graphic design, 3D design, art, packaging, visual imaging, visual arts, photography, editing, colour management, and more. By incorporating these technologies, these processes have been reinvented and optimized, leading to new outputs and results that previously took much longer to attain (Bhat, et al., 2019; Cannavò, et al., 2020; DeSouza, 2021; Lee, 2022; Liu and Nhung, 2022, Verganti, Vendraminelli and Iansiti, 2020). For example, AI-assisted higher-level thinking can enable employers to generate ideas and handle tasks more efficiently. These benefits can be expanded upon, opening up new possibilities for creatives. (Li, 2021; Liu, Ren and Liu, 2021; Nanne et al. 2020; Mazzone and Elgammal, 2019)

Adopting technology for creative purposes involves various tasks and processes, including setting up workflows, generating and preparing materials, simplifying projects, designing, making decisions, and solving problems. However, whether technology integration in creative work is limited remains debatable. After all, creativity arises from the imagination of original ideas, whereas software tools like AI rely

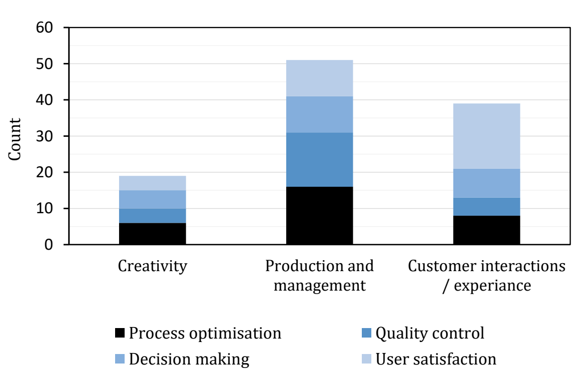

Figure 5: Evolution of the literature categories from 2021's pilot study to the present-day paper. It combines process optimization, quality control, decision making, and user satisfaction themes and clubs them into creativity, production / management, and customer interactions to better relay the information collected in three unique categories.

on historical data or pre-existing content from the web. This can lead to limitations and technical challenges when technology leads the creative process (Chandrasekera and Yoon, 2015; DeSouza, 2021; Edberg and Beck, 2020; Mazzone and Elgammal, 2019).

Throughout the articles, one of the recurring concerns in the design industry is the issue of copyright infringement and protection. When designs, art, or imagery are sourced from existing works, permission from the owner or creator is legally required. However, the risk of integrated technologies using an artist's work without proper attribution or compensation threatens the integrity of creative professions. Adopting intelligent algorithms could substantially transform the design industry, potentially leading to a more restrictive environment for creatives (Li, 2021; Sung, et al., 2021; Wan and Lu, 2021). For creative-based firms in the Graphic Arts sector, a cautious implementation may be required to preserve the foundation of their assets, which is their human capital. Regardless, larger organizations with more structured workflows could leverage these technologies strategically to streamline processes, minimize human touchpoints, and boost efficiency, particularly in areas where the creative process has a lower impact on the final output (Bhat, et al., 2019; Li, 2020; Ramírez-Durán, Berges and Illarramendi, 2021; Wang, et al., 2020).

4.2 Production and management

Creating successful customer experiences and interactions requires the implementation of robust production and management practices. This particular subcategory of articles focuses on the internal structures enabling the seamless integration of cutting-edge technologies throughout the organization's workflow, from the back to the front-end. Such practices emphasize the importance of leveraging the organization's assets, including its workforce and machinery, in tandem with these innovative immersive technologies. These technologies utilize intelligent algorithms that analyze past data and historical functions to facilitate decision-making, optimizing the organization's operations for human and machine inputs.

Just as technological advancements have transformed customer experiences and interactions, automation, AI, IoT, ML, XR, and BD are now revolutionizing the design of numerous granular processes involved in production and management. These technologies have been adopted across various industries, resulting in significant improvements in production efficiencies through reduced manual labor, prototyping, modeling, team structures, automation, and planning (Bochie, et al., 2021; Calış Duman and

Akdemir, 2021; Čolaković and Hadžialić, 2018; De Silva and Alahakoon, 2022; Garrido-Hidalgo, et al., 2019; Goyal, Sahoo and Sharma, 2021; Fadhilah, et al. 2018; Nanne, et al. 2020; Ramírez-Durán, Berges and Illarramendi, 2021; Zhang, 2022). Additionally, performance quality has been enhanced by leveraging historical data to optimize packaging methods for certain foods and 3D-printed parts (Delli and Chang, 2018; Goh, Sing and Yeong, 2020; Iuganson, 2018; Neil, 2019; Rechtin, Lewis and Zarko, 2019; Sa, et al., 2020; Wei and Xiangbo, 2020). Similarly, cost efficiency has been achieved by eliminating non-value touchpoints and automating workflows through intelligent software(Ashima, et al., 2021; Junjun, 2021; Knoll, et al., 2019). However, this digitization has also raised concerns about job security, heavy investments, time, and the need for training (Rodrigues, 2020). These integrated and intelligent algorithms can also assist with business structures affecting employee relationships, prioritizing human needs and interests through a front-end lens (Clarke, 2019; Dornelles, Ayala and Frank, 2022; Spuzic, et al., 2016; Takeuchi, et al., 2021).

Beyond the machinery, the impact of immersive technologies on company management has been studied, particularly regarding the relationship between employee adoption and these technologies (Chuah, 2019; Dwivedi, et al., 2022; Elbasheer, et al., 2022; Kinkel, Baumgartner and Cherubini, 2022; Peifer, et al., 2022; Luthra, et al., 2018; Makridakis, 2017; Westenberger, Schuler and Schlegel, 2022). The focus has been on workers' safety, well-being, health, and training procedures and their impact on the organization's decision-making process. Ethical and moral judgments have been crucial in evaluating previous work and employees' adoption of integrated technology. Since these areas are more personal and unique, deep learning has been employed to lead and touch these operations. Scheduling advancements, team structures, and human resourcing have been explicitly paired with intelligent software to manage these protocols (Ashok, et al., 2022; Davenport, et al., 2019; Elbasheer, et al., 2022; Margherita and Braccini, 2021; Moencks, et al., 2022). However, challenges arise in this robotic relationship if the software needs the correct criteria or historical data to engage with. Adverse effects in the articles include ethical implications, governance, privacy concerns, and politics.

4.3 Customer interaction/experience

The papers were selected based on similarities within a customer-centric approach and output. Specifically, when reviewing the front-end processes, one can expect to find the user satisfaction classification category, customer interaction, and experience subcategories.

Customer-centric experiences are observed in the service sector and involve physical touchpoints between the output and the customer. Companies must make customer-centric decisions about how their integrated technology will benefit frequent consumer desires and behavior to improve their product, process, or organization. This includes examining the consumer experience toward practical benefits and purchase intentions in an immersive setting (Dwivedi, et al., 2022; Dwivedi, et al., 2023; Li, et al., 2020; Li and Huang, 2020; Suh and Prophet, 2018; Sung, et al., 2021; Thompson, 2020). In this subcategory, the study of consumer desires among different demographics toward various integrated technologies was monitored. It was also found that consumer decision-making and internal evaluations of whether to adopt were based on the technology's benefits, experience, and final product results (Alkatheiri, 2022; Arsenijevic and Jovic, 2019; Dharmaputra, et al., 2021; Kopalle, et al., 2022; Peng, et al., 2022; Pfeiffer, 2018; Pelau & Barbul, 2021; Ulrich & Frank, 2021; Verma, et. al., 2021; Zhao, Zhang and Lee, 2022).

The specific integrated technologies discussed in these articles are focused on ML. These machines have been utilized to enhance customer experiences in various settings, such as retail markets, creative environments, and learning environments (Mazzone & Elgammal, 2019; Suh & Prophet, 2018). These technologies have been found to have actual availability and access to markets and are currently in the hands of consumers. The discussion of AI, IoT, XR, and BD was highlighted in these articles.

This analysis also included observing customer interaction and experiences from a negative standpoint. Consumers were found to have technological anxieties and evaluated integrated technologies as a disturbance, leading to distrust instead of desire. These negative attitudes and perceptions were projected toward assets such as VR glasses and topics related to ethical and robotic relationships (Dwivedi, et al., 2023; Herz and Rauschnabel, 2019; Li and Huang, 2020; Omrani, et al., 2022; Zerilli, Bhatt and Weller, 2022).

5. Conclusions

The main aim of this study was to provide a snapshot of the existing technologies in the last decade and how that impacted human perspectives and engagement with these technologies. It explored the pros and cons as well as challenges and future improvements. Overall, studies showed the positive impact of integrating various technologies in enhancing workflow automation, decision-making, consumer design, and engagement with products or services from AI art, prepared packaging compositions, and immersive retail experiences. On the other hand, certain articles discuss challenges such as recognizing the hesitancy and fear of the older generation in engaging with cutting-edge technology such as extended reality, ChatGPT, and other AI-related technologies due to various factors such as the fear of the unknown (Dwivedi, et al., 2023; Stanford, 2020). Along with the rise of automation and the adaptation of novel AI technologies such as Generative AI applications, the question of ethical consumption and the legal source of the training data used in various machine learning algorithms fed by those applications was also elaborated on in other articles.

The bright side remains that there are still opportunities for the successful and succinct adaptation of these technologies to aid in human capital. A successful adaptation must be accompanied by a substantial change management policy to ensure the sustainability of the service provided. Now we live in a competitive era where organizations are in a race to raise widespread awareness of available technologies and their implementation. In the digital world, companies recognize the significance of keeping up with IT infrastructure and technology and staying on top of the mind of consumers. If you miss the wave, you miss the younger generation's profit (Barredo Arrieta et al., 2020; Botvinick, 2022; Dharmaputra et al., 2021; Omrani et al., 2022; Trepanier, 2023; Westenberger et al., 2022).

As ongoing and current research at the Toronto Metropolitan University's (TMU) Creative School, this paper will serve as the basis on which further research will be conducted to cover broader sectors in the graphic communications and the creative industries that were not addressed in this current research, as well as contribute to providing clear and accessible evidence of a neglected research topic and one that is severely under-addressed within the field of graphic communications. In addition, advanced analytical methods will be implemented to provide comprehensive and organized research articles and introduce more focused knowledge clusters to accurately identify gaps in the available literature. In addition, this study would benefit from implementing keyword co-occurrence and cross-fertilization of selected field analysis techniques similar to the techniques that are used in other systematic literature review studies, which would provide another in-depth examination method to better understand the broad implementation of the investigated technologies. For example, some machine learning technologies were used to enhance overall performance optimization which lead to better decision-making. Analysis such as these would aid in the holistic approach considered in this paper to advance the graphic communications industry even further.

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