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Transformative Roles of Artificial Intelligence (AI) and Extended Reality (XR) in Revolutionizing Services.

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Abstract

Services are experiencing a significant transformation powered by emerging technologies, notably Artificial Intelligence (AI) and Extended Reality (XR). Therefore, the current study aims to uncover the transformative roles of AI and XR in services. A systematic literature review is conducted across relevant databases, such as Scopus, Google Scholar, and Web of Science, using keywords and their combinations such as "Artificial Intelligence (AI), Extended Reality (XR) and Services". Determined specific inclusion criteria for the studies, such as accessible articles from journals, English language, and contained the names in title, abstract, and keywords. Established exclusion criteria include studies that are not directly related to the central themes and literature that is not available in the required languages. Implemented a two-stage screening process; first by title and abstract, then full-text review, to determine eligibility for inclusion. Finally, a total of 34 studies were deeply reviewed. The review reveals the transformative roles of AI and XR in services, their evolution, their impact and application in various industries, and their connection with other themes. This study constitutes an effort to explore the depth of literature and develop the thematic framework on the convergence of AI and XR in services.

Keywords: *Artificial Intelligence; Extended Reality; Services; Literature Review.*

1. Introduction

Today, the service sector is experiencing a tremendous change, driven by the new technologies that are emerging in this arena, and most notably Artificial Intelligence (AI) and Extended Reality (XR) (Jha et al., 2023). Rather than just incremental improvements, these technologies are transformative in their approach to the delivery, experience and management of services (De Keyser et al., 2019; Jha et al., 2023). The adoption of AI and XR is increasingly vital for businesses seeking to maintain their competitive edge, improve customer experiences, and tap into new growth opportunities, as the world enters the era of "Industry 4.0" and "Industry 5.0" (Jha et al., 2023; Kamdjou et al., 2024).

AI is a rapidly developing technology and has been used across a number of different areas of the service sector to gain insight into needs of customers, automate tasks and provide personalisation (Gigante & Zago, 2023; Jha et al., 2023). AI-powered applications include virtual assistants, chatbots, predictive analytics, and optimization of real-time rendering, leading to more efficient and satisfying customer interactions (Gigante & Zago, 2023; Jha et al., 2023; Kamdjou et al., 2024). Conversely, the term Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) is collectively known as XR, and it is transforming the manner in which users interact with services by seamlessly merging the physical and digital realms (De Keyser et al., 2019; Jagatheesaperumal et al., 2024; Kong et al., 2023). XR technologies provide an immersive experience, such as visualizing products in their environment, participating in virtual training, and accessing remote services in real-time (Choi et al., 2019; Hegedus & Tick, 2023).

The convergence of AI and XR in the service sector is paving the way for innovative solutions and applications that were previously unimaginable (Jagatheesaperumal et al., 2024; Rokhsaritalemi et al., 2023). This study examines the transformative roles of AI and XR technologies in the services, their development, effects, application and implications, and how they relate to other topics.

2. Literature Review

2.1. Artificial Intelligence (AI)

Artificial Intelligence (AI) is a key technology driving transformation across various industries, offering solutions for automation (Jha et al., 2023), enhanced decision-making (Koshnicharova et al., 2022) and personalized experiences (Gigante & Zago, 2023). In other words, AI is the creation of computer programs that can model human actions and interactions in complex scenarios, gather and analyse information, think and reason about problems, and take decisions to accomplish a structured objective even in unexpected situations (Gigante & Zago, 2023). AI assigns machines the ability to perform cognitive functions typically associated with human brains, including perceiving, learning, interacting, and solving complex problems (Gigante & Zago, 2023). AI encompasses a range of techniques, including machine learning (ML), deep learning, natural language processing, and computer vision (Kamdjou et al., 2024; Santos et al., 2021).

2.2. Extended Reality (XR)

XR is an umbrella term that encompasses Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR) technologies (De Keyser et al., 2019; Jagatheesaperumal et al., 2024; Penaherrera-Pulla et al., 2024). XR aims to revolutionize how people interact with technology by blending virtual and physical worlds to create immersive experiences (Penaherrera-Pulla et al., 2024; Santos et al., 2021). XR technologies are relevant to all archetypes (De Keyser et al., 2019). XR comprises of three components: Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR). AR overlays digital images, videos, and information onto the user's real environment (De Keyser et al., 2019; Penaherrera-Pulla et al., 2024). AR enhances the real world by adding virtual elements (Santos et al., 2021). For example, the IKEA Place app allows users to place true-to-scale 3D furniture in their homes using their smartphones (De Keyser et al., 2019). VR creates computer-simulated 3D environments in which users are fully immersed, engaging one or more human senses (De Keyser et al., 2019; Penaherrera-Pulla et al., 2024). Volvo introduced a full VR test drive of its XC90 model as an example (De Keyser et al., 2019). MR combines elements of AR and VR by overlaying and anchoring digital objects within a real or digital environment (De Keyser et al., 2019; Penaherrera-Pulla et al., 2024). An example is RoboRaid, where gamers fight virtual robots that appear in their physical environment through Microsoft's HoloLens (De Keyser et al., 2019).

2.3. Evolution and Synthesis

The rapid evolution of technology is driving profound transformations across various sectors, as evidenced by the diverse research presented in the Timeline (Figure 1).

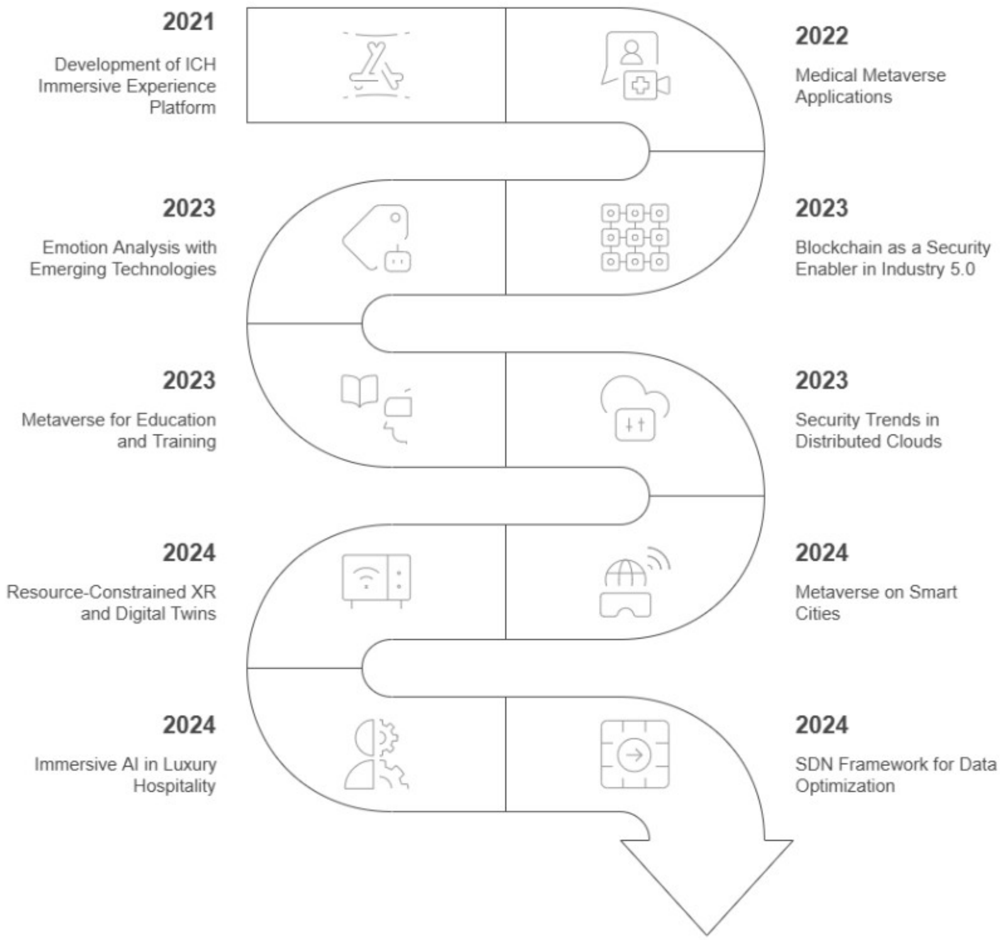

Figure 1. *AI and XR Evolution in Services (Source: Authors' own work).*

A central theme emerging from the studies throughout the trend in Figure 1 is the increasing integration of advanced technologies like Blockchain, Artificial Intelligence (AI), Extended Reality (XR), and the Metaverse into real-world applications, addressing challenges in security, service delivery, and user experience (Table 1). Verma et al. (2022) highlight the potential of Blockchain technology as a crucial security enabler in Industry 5.0. Their survey underscores the need for trusted control over industrial processes, proposing a reference architecture that integrates Blockchain to secure industrial boundaries. This focus on security is echoed in Santos et al. (2021), who review security trends in distributed cloud environments, emphasizing the role of Mobile Edge Computing (MEC) and Fog Computing (FC) in low-latency service delivery. They note the growing importance of Blockchain and Deep Learning, while also pointing out unexplored areas like Federated Learning and Intent-Based Networking. Similarly, Abou El Houda et al. (2024) contribute to the security domain by proposing an Adapt-SDN framework that optimizes data collection and feature selection, reducing computational complexity and improving detection performance.

Several studies highlight the potential impact of the Metaverse and XR technologies, with some specific examples from the e-commerce, automotive, and real estate sectors.The Metaverse and XR technologies are prominently featured in several studies, highlighting their growing impact across various industries, including e-commerce, automotive, and real estate. Cigliano et al. (2024) examine real-life services impacted by the Metaverse with a focus on the role of enabling technologies and Quality of Service (QoS) requirements in the fields of IoT, energy, and smart cities. They highlight the pivotal role of Generative AI, particularly Large Language Models (LLMs), in creating dynamic content and intelligent interactions. Kamdjou et al. (2024) delve into Resource-Constrained XR operated with Digital Twins (DT) in the

Industrial Internet of Things (IIoT), identifying research trends and the increasing interest in this area since Industry 4.0. In summary, the research by Jagatheesaperumal et al. (2024) delves into the ethical implications and data security in the context of using the Metaverse for education, training, and skill development. Pistola et al. (2021) demonstrate how XR and AI can be used to preserve Intangible Cultural Heritage (ICH) and provide immersive experiences to protect traditional dances and stories.

The omnipresent nature of AI is demonstrated in various studies. Earlier, Rokhsaritalemi et al. (2023) explored emotion analysis and its incorporation with the new technologies, emphasising that AI-based applications may be able to detect emotions in different contexts. The ability to comprehend and react to human emotions is important in developing more individualized and interesting experiences. Gonçalves et al. (2024) discuss the negative and positive effects of using immersive AI in the luxury hospitality industry, highlighting that although a functional and hedonic value of immersive AI may exist, it can also have detrimental effects on differentiation motives and perceived luxury value.

Lastly, Ramu et al. (2024), and Shao et al. (2023) discuss the application of such technologies in the health care industry. They highlight the growing interest in the Medical Metaverse, focusing on its potential applications, challenges, and future directions. This proves that it is not just the industrial, entertainment and gaming worlds that are being powered by the integration of new technologies but the critical sector of healthcare too.

Table 1. Review Synthesis

Author	Year	Themes/Variables	Context	Findings
Verma et al. (2022)	2023	Blockchain technology, Security, Privacy, Trust management.	Industry 5.0.	Blockchain is a viable solution to induce trusted control over industrial processes to secure the industrial boundaries.
Cigliano et al. (2024)	2024	Metaverse, IoT, Energy, Smart Cities, Quality of Service (QoS), GenAI, LLMs.	Real-life services.	GenAI, particularly LLMs, play a critical role in enabling the creation of dynamic content and intelligent interactions within the metaverse.
Kamdjou et al. (2024)	2024	Resource-Constrained XR, DT, IIoT, QoS, QoE, Security, AI/ML & Edge/Cloud.		Identifies research trends, key terms, and relationships between co-occurring terms.
Santos et al. (2021)	2023	Low Latency Service Delivery, Mobile Edge Computing (MEC), Fog Computing (FC), Micro-services, Hardware Acceleration, Smart Cities, XR, IIoT.	Self-driving cars	Reviews architectural concepts to enable application deployment in a continuum of virtual resources.
Rokhsaritalemi et al. (2023)	2023	Emotion Analysis, AI, Geographic Information Systems (GIS), XR, emotion recognition.	Emerging technologies.	Explores AI-based applications for identifying emotions in various contexts.
Gonçalves et al. (2024)	2024	Immersive AI, Traditional Hospitality, Behavioral Intentions, Need for Differentiation, Functional Value, Hedonic Value, Symbolic/Expressive Value, Financial Value, Anthropomorphism.	Hospitality	Immersive AI has a detrimental effect on customers' differentiation motives and perceived luxury value in luxury hospitality.
Jagatheesaperumal et al. (2024)	2023	Metaverse, XR, Internet of Everything (IoE), Education, Training, Skill Development, Data Security.	Education, training, and skill development.	Provides a detailed overview of existing literature, highlighting key challenges, potential opportunities, and future research directions.
Pistola et al. (2021)	2021	Intangible Cultural Heritage (ICH), XR, AI, Virtual Experience (VE), Emotion Extraction, Folk Dance	Entertainment	Provides AI tools for folk dance recognition, emotion extraction, and 3D visualization.

Author	Year	Themes/Variables	Context	Findings
		Recognition, 3D Visualization, Natural Language Processing (NLP).		
Abou El Houda et al. (2024)	2024	Adapt-SDN framework, SDN Controllers, Machine learning, Hyperparameter optimization.	Emerging technologies	Achieves reducing computational complexity and improving detection performance.
Ramu et al. (2024)	2022	Medical Metaverse	Healthcare.	Applications, challenges, and future directions of the metaverse for healthcare.
Shao et al. (2023)	2023	Medical Metaverse	healthcare.	application of the metaverse in healthcare.

3. Methods

This study adopts a Systematic Literature Review (SLR) methodology following the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021). SLR is the most rigorous approach to synthesising a body of evidence on a defined topic, offering transparency, reproducibility, and comprehensiveness that narrative reviews cannot match. Three major academic databases were searched: Scopus, Web of Science (WoS), and Google Scholar. These databases were selected for their broad disciplinary coverage spanning computer science, management, engineering, and social sciences all relevant to the AI-XR-services nexus. The search was restricted to publications from 2019 to 2024, capturing the post-Industry 4.0 maturation period when XR and AI integration in services began to accelerate meaningfully.

The following Boolean search string was applied across title, abstract, and keywords fields:

> *("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "Deep Learning") AND ("Extended Reality" OR "XR" OR "Augmented Reality" OR "AR" OR "Virtual Reality" OR "VR" OR "Mixed Reality" OR "MR") AND ("Service" OR "Service Industry" OR "Service Innovation" OR "Service Delivery" OR "Customer Experience")*

Inclusion criteria were applied as follows: (1) peer-reviewed journal articles or conference proceedings indexed in target databases; (2) publication in English between January 2019 and December 2024; (3) primary focus on AI and/or XR in service-related applications; and (4) full-text availability. Exclusion criteria included: studies without direct application to service contexts; purely theoretical works without empirical or applied grounding; duplicate publications; and grey literature such as white papers and technical reports.

A two-stage screening process was implemented. In Stage 1, titles and abstracts of all retrieved records were independently screened against the inclusion/exclusion criteria. In Stage 2, full texts of shortlisted papers were reviewed for eligibility. Disagreements between reviewers were resolved through consensus discussion. A standardised quality assessment rubric evaluated each study on: (1) clarity of research objective; (2) methodological rigour; (3) relevance to the AI-XR-services nexus; and (4) citation impact. Table 2 summarises the PRISMA process. A total of 34 studies were included in the final synthesis.

Table 2. PRISMA 2020 Protocol Summary

PRISMA Phase	Action Taken
Identification	Searched Scopus, Web of Science, and Google Scholar using Boolean strings: ("Artificial Intelligence" OR "AI") AND ("Extended Reality" OR "XR" OR "Augmented Reality" OR "Virtual Reality" OR "Mixed Reality") AND ("Services" OR "Service Industry" OR "Service Delivery")
Screening (Stage 1)	Title and abstract screened for relevance to AI, XR, and service contexts. Non-English, non-peer-reviewed, and unavailable full-texts were excluded.
Eligibility (Stage 2)	Full-text review against inclusion criteria: (1) peer-reviewed journal articles or conference proceedings; (2) publication years 2019–2024; (3) explicit focus on AI and/or XR in service applications.
Inclusion	34 studies included after full-text review. Studies were excluded if they lacked direct relevance to service contexts or duplicated findings without additional contribution.

PRISMA Phase	Action Taken
Quality Assessment	Each study assessed on: clarity of research objective, methodological rigor, relevance to AI/XR-service nexus, and citation impact. Disagreements resolved by consensus.
Data Extraction	Structured data extracted per study: authors, year, methodology, thematic focus, context, and key findings. Recorded in a standardised extraction template (Table 1).

Note: PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021). (Source: Authors' Own Work).

Data were extracted from each included study using a standardised template capturing: author(s), year of publication, methodology, thematic variables, service context, key findings, and relevance to the AI-XR nexus. Thematic analysis was subsequently applied to identify patterns, convergences, and tensions across the corpus. The thematic coding process followed Braun and Clarke's (2006) six-phase framework, producing the six transformative role categories reported in Section 4.

4. Findings

Findings from reviewing the literature present various applications of AI (Figure 2) and XR (Figure 3) in different services.

4.1. Applications of AI

Service Industries

AI, along with robotics and other technologies, can drive new business growth, increase revenue, improve differentiation, reduce operational costs, manage risks, and enhance customer experience in service industries such as banking, healthcare, insurance, and agriculture (Jha et al., 2023). The potential of AI in personalized banking is especially suitable since the human resources, processes, and data-management can be adapted (Gigante & Zago, 2023). It can cut down on usual tasks, enhance processes with machine learning, and bring out the potential of the locked data (Gigante & Zago, 2023). AI can provide customized recommendations, automated alerts, simplified lending processes, and hyper-tailored investment guidance to customers, based on the detailed analytics provided (Gigante & Zago, 2023). It assists the service providers in asset management, customer service, fraud management and algorithmic trading (Gigante & Zago, 2023).

AI can spot diseases, with virtual or augmented reality helping patients cope with discomfort (Jha et al., 2023). AI can automate routine tasks in healthcare, saving effort and time for skilled professionals (Ramu et al., 2024). AI can derive insight at more incredible speed, accuracy, and unique insight in insurance (Jha et al., 2023). Machine learning applications are improving claim processing time and getting automated, resulting in less manual intervention (Jha et al., 2023). AI solutions in agriculture can analyze and observe climate patterns to optimize yields and cut nutrition manufacturing expenses (Jha et al., 2023). Digital and autonomous technology can upsurge the effectiveness with which involvements such as irrigation water, fertilizers, and pesticides are implemented (Jha et al., 2023).

Industry 5.0

AI is a core component of Industry 5.0, facilitating collaboration between humans and cobots, optimizing performance, and ensuring security and privacy (Kamdjou et al., 2024; Verma et al., 2022). AI plays a central and multifaceted role in Industry 5.0, driving advancements in automation, human-machine interaction, and customized production and it serves to integrate human influence in automation processes, enhancing control and modeling systems (Verma et al., 2022). Moreover, its key applications include combining human expertise with AI to design precise control and cognitive abilities, mass customization by analyzing user demographics, suggestions, and design features of competitive products to design tailored products that satisfy end-user needs, human-robot collaboration leading to synergism and alignment with business models guided by human instructions processed via Machine Learning (ML) and Deep Learning (DL) algorithms, improving supply chains by using AI-driven pipelines to ensure security enforcement, access control, authentication, and automated service-oriented behaviors, predictive quality measurement to monitor automated functions and minimize bias in expected output and finally boosting green initiatives contributing to environmental stewardship, ecosystem protection, and efficient resource use (Verma et al., 2022). AI-driven technologies, including Machine Learning (ML), Deep Learning (DL), and Reinforcement Learning (RL) models, support automation (Verma 2022). However, the rise of AI also presents challenges, such as the need for trusted datasets and the ethical and societal impacts of automation (Verma et al., 2022).

Crowd Management (CM)

AI can streamline and advance how populations and crowds are managed worldwide by evaluating photos from cameras, traffic, or crowd motions to support, automate, and enhance planning and decision-making (Koshnicharova et al., 2022). Also, AI plays a significant role in emergency services by facilitating the analysis of people flows to design emergency evacuation scenarios that improve safety, emotion detection to detect children's emotions, monitor emotional states, and provide valuable support to parents and caregivers (Koshnicharova et al., 2022). Swarm robotics, as a component of AI in traffic management, can help solve the problem of traffic jams and even eliminate the need for traffic signals (Verma et al., 2022).

Extended Reality (XR)

AI optimizes various aspects of XR performance, including real-time rendering, adaptive streaming, and predictive analytics, balancing latency and performance in resource-constrained environments (Kamdjou et al., 2024).

Affective Computing

AI techniques are used to detect, interpret, and respond to human emotions, enhancing interactivity between humans and technology (Amer et al., 2023; Rokhsaritalemi et al., 2023). Applications of AI in affective computing include emotion recognition by analyzing facial expressions, speech, text, and physiological signals to recognize human emotions (Amer et al., 2023). It enables the smooth embedding of emotion analysis into various scenarios, thereby assisting with the detection and response of emotions in real-time, improving service quality and personalized service experience (Rokhsaritalemi et al., 2023). For instance, in the context of connected healthcare, IoT devices can be used to collect and analyze patients' voice and image data while classification methods can be used to identify their emotions to provide caregivers with effective responses, especially when they are dealing with pain detection (Rokhsaritalemi et al., 2023).

AI is used to create personalized exergames for motor rehabilitation by detecting emotions with positive and negative results and then adapting game objects to provide an appropriate game for the patient (Rokhsaritalemi et al., 2023). AI is also used to develop intelligent driving systems, displaying details of nearby drivers, including their emotions (Rokhsaritalemi et al., 2023). AI's ability to understand and respond to human emotions makes interactions between humans and machines more natural and empathetic (Amer et al., 2023). The ultimate goal is to create a seamless interaction where machines understand not only the explicit commands but also the underlying emotional context to enhance the user experience and foster more meaningful connections (Amer et al., 2023).

Edge Computing

AI is crucial for edge computing, with research focusing on novel practical and algorithmic foundations to ensure efficiency, scalability, security, privacy, and fairness in edge computing systems (Chen et al., 2024). AI has a multitude of applications in edge computing, enhancing its capabilities and enabling new functionalities across various industries (Chen et al., 2024). Edge computing, which brings data processing and analysis closer to the data source, benefits significantly from the integration of AI, and the use of AI algorithms and models at the edge enables local processing and decision-making (Kamdjou et al., 2024).

Its key applications in edge computing includes edge intelligence techniques, such as ML and AI algorithms, enable real-time analysis and decision-making within the edge environment, enhancing the responsiveness and autonomy of applications (Kamdjou et al., 2024), intrusion detection (Abou El Houda et al., 2024), improved privacy (Chen et al., 2024), detection of security threats (Abou El Houda et al., 2024), AI-driven next-generation technologies through a combination of analytical, experimental, and empirical instruments, especially with target use-inspired research (Chen et al., 2024) and network management Santos et al. (2021). Overall, AI in edge computing facilitates real-time insights, reduces latency, and improves privacy, making it a crucial component of next-generation networks and applications (Chen et al., 2024; Santos et al., 2021).

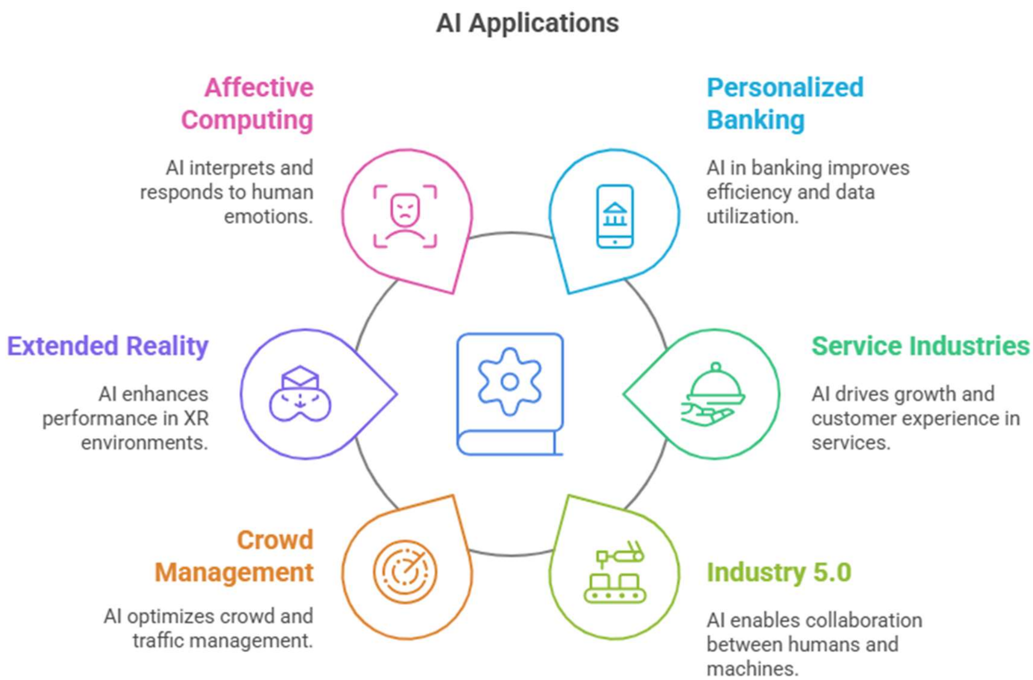

Figure 2. *AI Applications (Source: Authors' Own Work).*

4.2. Applications of XR

Industry 4.0 and 5.0

Extended Reality (XR) has many applications in Industry 4.0 and Industry 5.0 and is a cornerstone technology that improves visualization, collaboration, training, and design processes (Kamdjou et al., 2024). It encompasses AI technologies that enable people to interact with machines in new ways, and change the relationship between physical and virtual worlds (Cigliano et al., 2024; Kamdjou et al., 2024; Penaherrera-Pulla et al., 2024).

XR, along with Digital Twin (DT) technology, is a next-generation technology that can revolutionize multiple facets of Industry 4.0 and serve as a cornerstone for Industry 5.0 (Kamdjou et al., 2024). It enhances efficiency, safety, and collaboration within manufacturing processes (Kamdjou et al., 2024). General applications of XR include training and skill development by immersive training simulations for real-life scenarios, offering hands-on experience in risk-free environments (Jagatheesaperumal et al., 2024; Kamdjou et al., 2024). It enhances learning and knowledge retention, especially among children, and is easy to scale up or down, becoming more affordable over time (Hegedus & Tick, 2023). XR coupled with Digital Twins (DT) facilitates the scaling up of data, enabling comprehensive evaluations, expediting business processes, enhancing productivity, and fostering faster innovation while reducing costs and risks (Kamdjou et al., 2024). It reinstates the "human touch" into production processes, enabling customers to customize their orders, and transforming conventional manufacturing operations into smart processes that are more efficient than cloud-based systems (Verma et al., 2022). XR allows for effective immersion in a virtual environment, enabling the visualization and interactive exploration of relevant information (Kamdjou et al., 2024). This includes visualization in logistics, supply chain, maintenance, product design, and assembly (Kamdjou et al., 2024).

Other applications include human-robot collaboration through XR interfaces, enabling operators to engage with DT for dynamic process visualization that bridges the gap between human and robot interactions in shared workspaces, maintenance and troubleshooting, smart manufacturing system (SMS), and eco-friendly and sustainable practices (Kamdjou et al., 2024). For example, UNMAS uses VR goggles for humanitarian workers in Iraq to practice identifying EO hazards, the Danish Demining Group transforms risk education books into AR for children in Ukraine and Golden West Design Lab develops an AR/VR application for training EORE teams in Cambodia (Kamdjou et al., 2024).

Education and Training

XR has a wide range of applications in education and training, enhancing learning experiences across various fields (Jagatheesaperumal et al., 2024; Pistola et al., 2021). It can be applied in diverse areas such as general education (Pistola et al., 2021), medical training (Jagatheesaperumal et al., 2024), industrial skills development (De Keyser et al., 2019), and military preparedness (Jagatheesaperumal et al., 2024). XR brings educational services to students in remote places, minimizing the need to travel and emphasizing interactive and collaborative remote education (Jagatheesaperumal et al., 2024). Students can gain immersive learning experiences and feel physically present in collaborative classroom environments regardless of their location (Jagatheesaperumal et al., 2024). It is effective for user engagement, learning, and knowledge retention (Hegedus & Tick, 2023). It is particularly useful for certain target groups, such as children, making it more effective for them to respond to and retain information (Hegedus & Tick, 2023). For example, learning about the solar system through interactive VR services, and enhancing the pre-service and in-service experience of teachers, through virtual mainstreaming, rendering spatial sound along with XR-enabled video streaming services (Jagatheesaperumal et al., 2024).

XR tools enable realistic simulations in medical education (Jagatheesaperumal et al., 2024). Training in medical fields can be enhanced through the use of XR by self-practicing and learning at one's own pace for core nursing skills (Jagatheesaperumal et al., 2024). For example, touch-free interfaces and 3D visualization (Jagatheesaperumal et al., 2024), training for lung cancer surgery through the metaverse in a smart operating room (Jagatheesaperumal et al., 2024; Kamdjou et al., 2024), Ophthalmoscopy simulators to improve procedural success and reduce complication rates in ophthalmic surgery, and holographic rendering and depiction of anatomical structures for better clinical care (Jagatheesaperumal et al., 2024).

XR offers virtual training scenarios for Frontline Employees (FLEs) (De Keyser et al., 2019). For example, Walmart uses VR training to help FLEs better interact with customers, resulting in higher evaluations and training satisfaction (De Keyser et al., 2019). It can also provide adaptive and sustainable education, critical thinking opportunities, and better communication and collaboration (Jagatheesaperumal et al., 2024). It can train the workforce on maintenance and assembly tasks (Jagatheesaperumal et al., 2024). It is used to train workers to carry out maintenance and inspection processes in the aviation industries, simulate construction projects using a BIM-based XR process/workflow and guide with visual aids on correct welding positions and procedures for arc welding training (Jagatheesaperumal et al., 2024).

XR is also applied to replicate environments for training soldiers more realistically, preparing them for dynamic adaptation (Jagatheesaperumal et al., 2024). It helps reduce expenses involved in traveling and shifting goods for troops' exercises and allows training with special armed equipment without putting them at risk (Jagatheesaperumal et al., 2024). Through DIS protocol, different military simulations with the support of advanced high-level architectures are used for providing rich collaborative training and preparation of war strategies (Jagatheesaperumal et al., 2024).

Retail Services

XR (Extended Reality) technology has various applications in retail environments (Koshnicharova et al., 2022). XR applications allow customers to preview products or services (De Keyser et al., 2019). For example, IKEA's AR app allows customers to visualize furniture in their homes (De Keyser et al., 2019). Accurate positioning data from IoT sensors can help retail managers understand customer movement within a shopping area (Koshnicharova et al., 2022). This data can reveal the most visited sections and how promotions influence shoppers' decisions (Koshnicharova et al., 2022). For example, Supermarkets can use data about customer shopping habits to optimize the arrangement of goods and can open additional check-out points on demand based on customer traffic (Koshnicharova et al., 2022). Overall, XR has the potential to greatly enhance e-commerce experiences and reduce costs (Jagatheesaperumal et al., 2024).

Healthcare

XR (Extended Reality) has numerous applications and is significantly impacting the healthcare sector (Bariah et al., 2020; Hegedus & Tick, 2023; Mozumder et al., 2023; Verma et al., 2022). XR in healthcare can improve medical procedures, training, education, and patient experience (Mozumder et al., 2023). It can further improve data representation in medical applications, such as facial emotion recognition systems for patients with major depressive disorder (Rokhsaritalemi et al., 2023). It is also used for medical training and remote assistance (De Keyser et al., 2019; Jagatheesaperumal et al., 2024).

General applications of XR in healthcare include training and education, including AR, VR, and MR, that is being integrated into medical education to train doctors by replicating intricate real-time procedures and disseminating knowledge on the cellular level of the human anatomy (Mozumder et al., 2023). It enables students and teachers from different parts of the world to meet in a virtual environment regardless of their real-world location (Jagatheesaperumal et al., 2024). Cobots enable telesurgery in Industry 5.0, connecting surgeons and patients through responsive networks with low latency (Verma et al., 2022) and the metaverse provides tools for effective planning and diagnosis of diseases (Mozumder et al., 2023).

XR is used for physical therapy and rehabilitation, such as stroke recovery and physical therapy workouts and used for online therapy and telemedicine (Mozumder et al., 2023). VR and AR allow for improved visualization and simulation in medical procedures, leading to better outcomes and reduced risks (Mozumder et al., 2023). VR helps patients in getting drug-free pain treatment without clinical care environments (Mozumder et al., 2023). XR coupled with digital twins technologies such as Few-Shot Learning and Meta-Learning enhance the precision of digital twins, while Continuous Learning facilitates their perpetual adaptation to individual alterations, ensuring their evolution in tandem with users (Kong et al., 2023).

Urban Services

XR has several applications for improving urban services (Rokhsaritalemi et al., 2023). It can provide valuable insights into individuals' needs and preferences in different settings (Rokhsaritalemi et al., 2023). Specific applications of XR in urban services include emotionally intelligent XR in a virtual forest game, that can adjust fog and audio levels by using a user's emotional state to improve user engagement and immersion in the virtual environment (Rokhsaritalemi et al., 2023). Emotionally intelligent XR can also change virtual elements in a game, such as having a virtual avatar employ a user's emotional state (Rokhsaritalemi et al., 2023). Empowering AI with emotional intelligence can create childcare applications that detect a child's emotions and provide appropriate services, such as swinging the cradle when the child cries (Rokhsaritalemi et al., 2023). Location-emotion-aware services can recommend routes based on the mood of the user to elevate their emotional state (Rokhsaritalemi et al., 2023). Crowd

Management (CM) techniques are vital in channelizing data to help design mobile networks, control emergencies, and plan infrastructures (Koshnicharova et al., 2022). A public system, such as the transportation system, can benefit significantly from CM. Both pedestrian and vehicle traffic management can take advantage of CM; for example, using IoT solutions available in smart cities, traffic can be analyzed and optimized (Koshnicharova et al., 2022). Moreover XR is applied in building and developing smart buildings and industrial processes (Keramidas et al., 2020), Safety and disaster response (Choi et al., 2019) and Mobile Extended Reality (XR) cultivating a more immersive, realistic, and interactive human experience (Kong et al., 2023).

E-commerce

XR (Extended Reality) has respective applications in E-commerce that improves many aspects of online shopping, and customer experience (De Keyser et al., 2019; Jagatheesaperumal et al., 2024). It enhances e-commerce experiences and reduces costs in travel and information sharing (Jagatheesaperumal et al., 2024). Specific applications of XR in E-commerce include personalized recommendations to make tailored suggestions for new users, using clickstream recommender algorithms to evaluate and compare products (Verma et al., 2022). AR (Augmented Reality) allows customers to overlay digital images of products onto their physical environment to visualize the products in their own space before making a purchase. For example, IKEA launched an AR app that allows customers to place 3D furniture in their homes through their smartphone (De Keyser et al., 2019). VR (Virtual Reality) technologies offer computer-simulated 3D environments that users can fully immerse themselves in (De Keyser et al., 2019). Volvo, for instance, introduced a full VR test drive of its XC90 model (De Keyser et al., 2019).

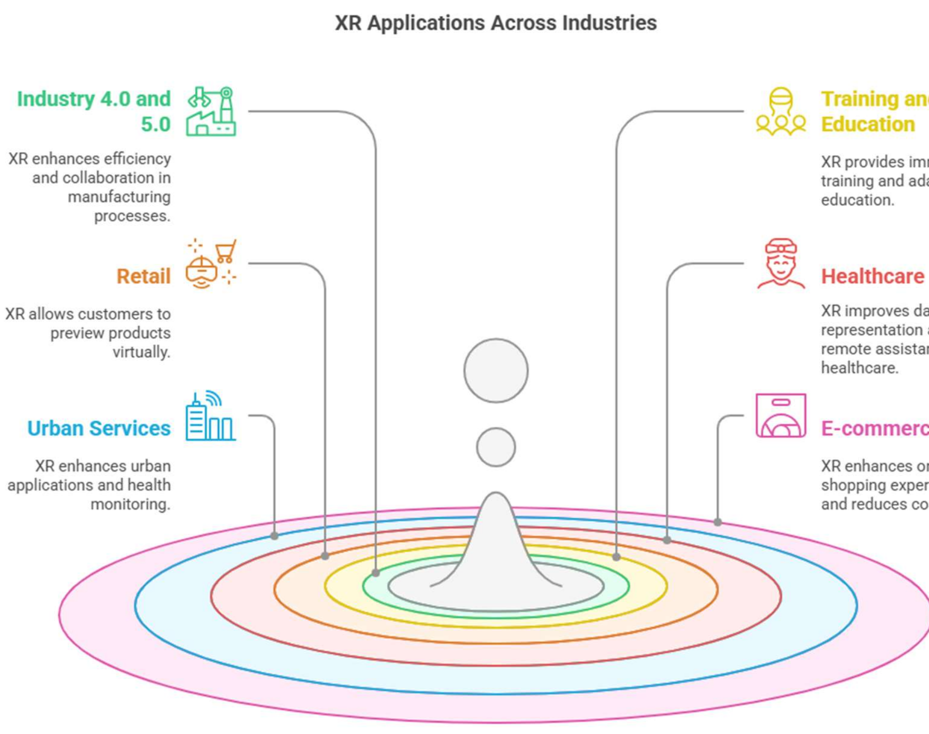

Figure 3. *XR Applications (Authors' Own Work).*

4.3. Mapping of AI and XR

AI and XR are thematically connected with some important concepts that are discussed below (Figure 4).

6G networks and Internet of Intelligent Things (IoIT)

AI is considered a key component in the development of 6G networks and the Internet of Intelligent Things (El Mettiti & Oumsis, 2022; Kong et al., 2023). The synergistic interplay between 6G and IoIT, augmented by AI, enables novel capabilities such as energy-efficient computing, endogenous safety and security, and ubiquitous intelligence (Kong et al., 2023).

Metaverse

AI is one of the main pillars for building the metaverse, with other technologies such as Digital Twin and IoT also playing critical roles (Cigliano et al., 2024). AI, particularly Generative AI (GenAI), is essential for creating dynamic content and intelligent interactions within the metaverse, allowing for personalized avatars, realistic dialogues, and adaptive interfaces (Cigliano et al., 2024). XR technologies like VR, AR, and MR are also integral to the metaverse, providing immersive experiences and enabling human interaction within virtual environments (Cigliano et al., 2024).

Edge computing

AI's functionality, efficiency, heterogeneity, and trustworthiness are major challenges in delivering next-generation edge computing systems (Chen et al., 2024). Edge intelligence focuses on distributed AI to contribute to XR in resource-constrained environments, optimizing computational resources, network bandwidth, and storage capacity based on the demands of XR with Digital Twin simulations (Kamdjou et al., 2024).

Digital Twins (DT) and Industrial Internet of Things (IIoT)

XR, alongside Digital Twins in the Industrial Internet of Things, is seen as a promising next-generation technology, with the potential to revolutionize Industry 4.0 and serve as a cornerstone for Industry 5.0 (Kamdjou et al., 2024). AI/ML are used to optimize XR performance in conjunction with Digital Twins, addressing challenges related to computing power, energy consumption, and memory in resource-constrained environments (Kamdjou et al., 2024).

Emotion-Intelligent Systems

The fusion of emotions with AI and XR heralds a new era of emotion-driven intelligent systems (Rokhsaritalemi et al., 2023). Emotionally intelligent XR systems can adjust their content and environment based on user emotions, leading to more personalized and engaging experiences (Rokhsaritalemi et al., 2023). AI can also be empowered with emotional intelligence to create applications that detect and respond to human emotions (Rokhsaritalemi et al., 2023).

Education

XR technologies enhance educational services by minimizing the need to travel and emphasizing interactive and collaborative remote education (Jagatheesaperumal et al., 2024). AI also contributes to making a significant impact on creativity in educational services through the metaverse (Jagatheesaperumal et al., 2024).

Smart Manufacturing System (SMS)

The integration of XR with Digital Twin (DT) holds great potential to enable real-time monitoring, predictive maintenance, and optimization of SMS in future industry (Kamdjou et al., 2024).

Cyber-Physical Systems (CPS)

Extended Reality solutions that increase situational awareness for human users and operators are being considered throughout the CPSoS lifecycle (Keramidas et al., 2020).

Affective Communication

Edge Intelligence and Artificial Intelligence can be used to extract and encode emotions at one edge, and communicate a low-footprint encapsulation of such emotions at the other edge, which can be especially useful in medical settings (Amer et al., 2023).

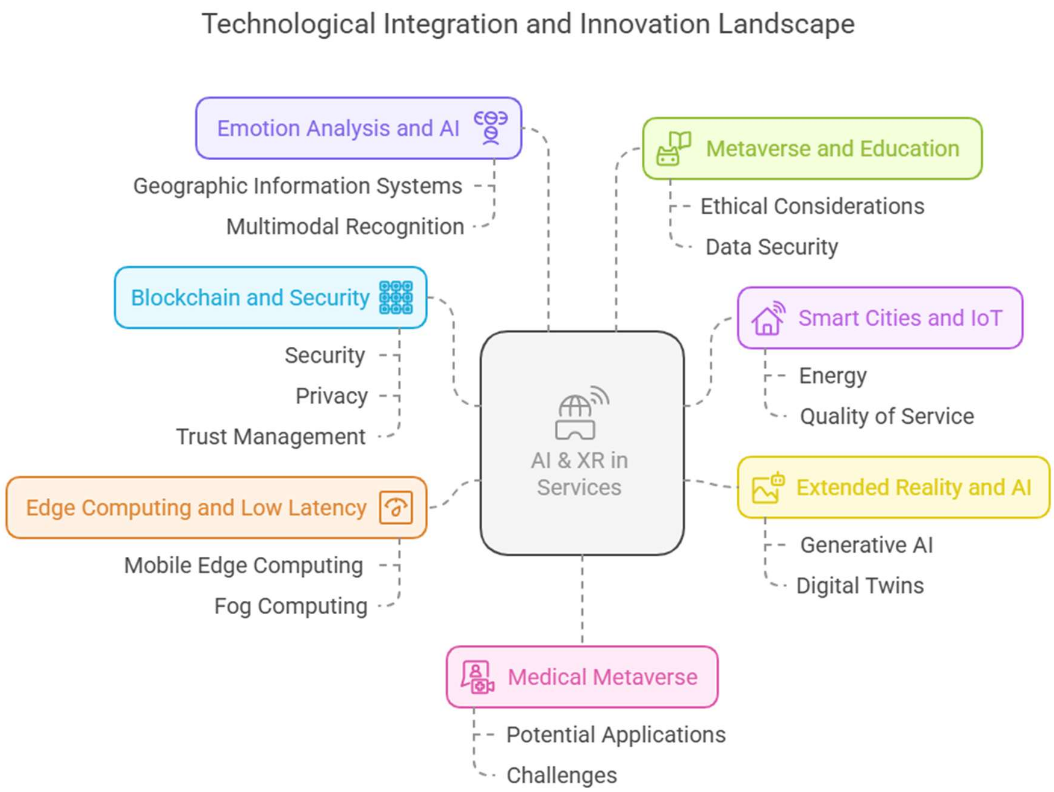

Figure 4. *Thematic mapping of AI & XR in services (Source: Authors' own work).*

4.4. Implications

AI and XR research are leading to new practical and algorithmic foundations to ensure functionality, efficiency, scalability, security, privacy, and fairness of AI solutions adopted in future edge computing systems (Chen et al., 2024). This involves developing novel causality analysis methods for AI models to handle unforeseen circumstances based on out-of-distribution data analysis, and techniques to enable efficient deployment and execution of AI models while automating model design by considering system heterogeneity (Chen et al., 2024). Research in AI and XR contributes to transforming service deployments from traditional monoliths to loosely coupled containers, while hardware-based accelerators push the boundaries of hardware platforms to support softwarized network functions (Santos et al., 2021). Integrating Machine Learning (ML) and AI in network management is also leading to self-driving networks, which may emerge as a potential solution for inappropriate human intervention (Santos et al., 2021).

XR coupled with Digital Twins (DT) helps operators, physicians, and learners improve qualifications, competencies, skills, or knowledge through real-life scenarios from real situations, providing an opportunity to learn-by-doing via hands-on practice (Kamdjou et al., 2024). This helps to reduce the time and cost factors that plague many Industry 4.0 design processes (Kamdjou et al., 2024). Embedding AI into immersive hospitality settings influences customers' differentiation motives and luxury value, reducing the intention to use AI recommendations (Gonçalves et al., 2024). Studies show that immersive AI can have a detrimental effect on perceived luxury value, especially when the service highlights differentiation motives (Gonçalves et al., 2024).

Combining emotion data with AI and XR creates more advanced and personalized systems that can enhance user experiences while also providing insights for businesses and organizations to better understand their audiences (Rokhsaritalemi et al., 2023). This includes developing emotionally intelligent XR systems that can adjust their content and environment based on user emotions and empowering AI with emotional intelligence to create applications that detect and respond to human emotions

(Rokhsaritalemi et al., 2023). Metaverse platforms, entwining XR and IoE (Internet of Everything) technologies, enhance training and skill development (Jagatheesaperumal et al., 2024). XR provides teachers and learners with opportunities for critical thinking, better communication, collaboration, and a higher level of creativity (Jagatheesaperumal et al., 2024). AI-generated characters can also support personalized learning and well-being (Jagatheesaperumal et al., 2024).

As AI technologies become more pervasive, it is crucial to address their ethical and social implications (Kamdjou et al., 2024). This involves delving into ethical considerations such as bias and fairness in algorithmic decision-making, accountability and transparency in AI systems, and the impact of AI on employment and societal structures (Kamdjou et al., 2024). Research in this area contributes to developing ethical guidelines and policies that promote the responsible deployment and adoption of AI systems (Kamdjou et al., 2024).

5. Conclusion

This study examined the transformative role of Artificial Intelligence (AI) and Extended Reality (XR) in reshaping service delivery, customer experience, operational efficiency, and innovation across contemporary service industries. Using a systematic literature review guided by PRISMA 2020, the study synthesised evidence from 34 relevant studies published between 2019 and 2024. The findings show that AI and XR are no longer peripheral technologies; they are becoming core service enablers across healthcare, banking, education, retail, manufacturing, urban services, hospitality, and e-commerce. AI contributes through automation, predictive analytics, personalisation, affective computing, and intelligent decision-making, while XR strengthens immersion, simulation, training, visualisation, remote assistance, and customer engagement. The review also shows that the convergence of AI and XR creates deeper value through metaverse applications, digital twins, edge computing, emotion-intelligent systems, and Industry 5.0 service models. However, these gains are not automatic. Issues of ethics, privacy, algorithmic bias, security, infrastructure readiness, and user trust remain critical. Future research should therefore move beyond describing applications and examine adoption outcomes, governance models, and responsible implementation frameworks.

Declarations

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon request.

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