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Web 4.0 and Beyond: Toward a Symbiotic and Emotionally Intelligent Internet Architecture

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Abstract

The evolution of the Internet reflects a continuous transformation from the early static Web 1.0 to the interactive and collaborative Web 2.0, and later to the data-driven intelligent Web 3.0. Each developmental phase has reshaped how people produce, exchange, and interact with information in the digital world. Today, society stands on the edge of Web 4.0 — an era frequently referred to as the "intelligent and emotional web." This stage represents the convergence of emerging technologies, such as artificial intelligence (AI), the Internet of Things (IoT), big data, and cloud computing, to create systems capable of intuitive, adaptive, and emotionally responsive interaction. Web 4.0 applications are already being used in intelligent assistants, predictive healthcare, and context-aware digital services, all of which enhance the relationship between humans and machines. Looking beyond, the anticipated Web 5.0 aims to establish a fully symbiotic relationship in which digital systems demonstrate emotional intelligence through brain–computer interfaces and immersive mixed reality experiences. In the future, Web 6.0 may evolve into an autonomous and self-learning network capable of fostering collective human–machine intelligence. This study discusses the transition from Web 3.0 to Web 4.0, exploring the driving technologies, emerging applications, and potential societal impacts, while also addressing the ethical and security challenges that accompany these transformations.

Keywords

Web 4.0, Symbiotic Internet, Emotional Intelligence in AI, Human–Machine Interaction, Affective Computing, Internet of Things (IoT), Artificial Intelligence, and Brain-Computer Interface.

Introduction

1.1 Evolution of the Web

Since its inception by Tim Berners-Lee in the early 1990s, the World Wide Web has undergone multiple evolutionary stages, each reshaping digital interaction, communication, and knowledge exchange [Berners-Lee, 1991].

1.1.1 Web 1.0 – The Static Web (1990s): The earliest version of the web, known as Web 1.0, primarily consisted of static, text-based pages designed for information viewing. This enabled one-way communication, where users could only consume content without participating or contributing [O'Reilly, 2005]. Although basic, it was revolutionary in establishing the foundation for global digital connectivity.

Web 2.0 – The Interactive and Collaborative Web (2000s): The emergence of Web 2.0 introduced interactivity, allowing users to consume, create and share information. This phase gave rise to user-generated platforms such as social networks, blogs, and wikis, where community participation became central [Kaplan & Haenlein, 2010]. The participatory nature of Web 2.0 has democratized information creation, fostered e-commerce, and expanded online learning and global collaborations.

1.1.3 Web 3.0 – The Semantic and Intelligent Web (2010s–Present): Web 3.0, often labeled as the "semantic web," advanced beyond user interactivity by making data machine-readable and context-aware. Artificial intelligence (AI), blockchain, and the Internet of Things (IoT) have played crucial roles in enabling automated, personalized, and decentralized services [Berners-Lee et al., 2001; Gartner, 2019]. This era has introduced virtual assistants, recommendation systems and decentralized applications (dApps). However, despite their intelligence, interactions remain largely cognitive and lack emotional understanding.

1.2 The Need for a More Symbiotic and Emotionally Aware Web

Although Web 3.0 has improved automation and personalization, it still struggles to interpret human emotion and intention. Human communication is not purely logical; it involves empathy, trust, and emotional depth [Picard, 1997]. Existing systems analyze enormous datasets but fail to respond meaningfully to users' emotional cues [Cowie et al., 2011].

In critical fields such as healthcare, governance, education, and customer experience, these limitations create a demand for systems that can emotionally engage with and adapt to the human context. This necessity forms the basis for Web 4.0, an envisioned digital ecosystem characterized by intelligence, empathy and responsiveness.

Web 4.0 aims to create two-way symbiotic interactions between humans and machines. It goes beyond semantic processing to incorporate emotional intelligence, affective computing, and adaptive real-time behavior [Yarosh, 2020]. Advanced technologies such as brain–computer interfaces (BCIs), affective AI, immersive virtual environments, and 5G/6G networks contribute to this evolution [Tegmark, 2017]. For instance, emotionally aware AI can analyze tone, gestures, and facial expressions to adjust responses, thereby increasing user comfort and trust.

This stage represents a paradigm shift from the web as a mere tool for information retrieval to an emotionally aware digital companion capable of empathy, anticipation, and human-like understanding.

1.3 Toward Web 4.0 and Beyond

Web 4.0 does not merely signify technological enhancement; it represents a deeper cultural and societal transformation. It envisions a world in which machines and humans interact through mutual understanding and emotional awareness, seamlessly integrating technology into daily lives [Fuchs, 2017].

Future developments, such as Web 5.0, sometimes described as the "Empathic Web," may further merge human consciousness with digital intelligence, fostering emotionally intelligent interactions and direct human–machine collaboration [Sestino et al., 2020]. However, achieving this vision raises complex ethical and privacy concerns regarding data, consent, and emotional manipulation.

Recent advancements in computational intelligence have demonstrated the potential of integrating analytical modelling, numerical methods, and machine learning techniques to address complex systems characterized by uncertainty, nonlinear behaviour, and dynamic interactions. Sahani et al. (2026) investigated hybrid analytical–numerical–machine learning frameworks that combine mathematical theories, stochastic modelling, and data-driven learning mechanisms for improved decision-making, risk management, and uncertainty quantification. Their studies highlighted that traditional analytical and numerical approaches can be strengthened through machine learning-based prediction and adaptive learning, enabling more robust and efficient solutions for complex deterministic and stochastic problems.

The application of hybrid computational frameworks has been further explored in management systems, where uncertainty-aware models are required for operational stability, risk forecasting, and strategic decision support. Sahani et al. (2026) proposed integrated architectures incorporating fractional stochastic modelling, robustness analysis, and neural filtering approaches to improve reliability under deep uncertainty. These approaches demonstrate the importance of combining probabilistic modelling with intelligent algorithms for managing complex decision environments. Moreover, hybrid analytical–numerical–machine learning methodologies have been extended to healthcare management, dental practice systems, and biotechnology-related applications, where they support resource optimization, risk assessment, and adaptive decision-making.

Overall, the existing literature indicates that hybrid intelligent frameworks provide a promising pathway for bridging the limitations of conventional mathematical and statistical approaches. By integrating theoretical modelling with machine learning capabilities, these approaches enhance prediction accuracy, computational stability, and uncertainty handling. However, further research is required to develop generalized, scalable, and domain-independent hybrid frameworks capable of addressing highly complex real-world systems with evolving uncertainties.

The transition from Web 1.0 to Web 4.0 highlights humanity's continuous effort to create digital systems that mimic both cognitive and emotional intricacies. This study explores the technological base, social implications, and moral questions surrounding this new phase of the web.

1.4 Objectives of the Study

General Objective

This study explores the evolution of Web technologies toward Web 4.0 and beyond, focusing on intelligent, emotionally aware, and symbiotic human–machine interactions enabled by emerging technologies.

Specific Objectives

To analyze the evolution from Web 1.0 to Web 4.0.

To examine the technologies driving Web 4.0.

This study explores the applications of emotionally intelligent web systems.

To identify the challenges and ethical concerns of Web 4.0.

Future developments such as Web 5.0 and Web 6.0 should be investigated.

Literature Review

The evolution of the web from Web 1.0 to Web 4.0 has been widely studied in the fields of Artificial Intelligence (AI), human–Computer Interaction (HCI), and emerging web technologies. Researchers have primarily focused on semantic intelligence, decentralized systems, emotional AI, and intelligent human–machine communication.

2.1 Previous Studies on Web 3.0 and Web 4.0

Berners-Lee et al. introduced Web 3.0 as the “Semantic Web,” where machines can intelligently understand and process information through linked and machine-readable data (Berners-Lee et al., 2001). Later studies described Web 4.0 as the “Symbiotic Web,” emphasizing intelligent, context-aware, and emotionally responsive interactions between humans and machines (Anderson & Rainie, 2012; Sadiku et al., 2017). Researchers have identified AI, IoT, blockchain, cloud computing, and immersive technologies as major foundations of Web 4.0.

Several studies have also highlighted that Web 4.0 aims to create ubiquitous and personalized digital environments where systems can proactively respond to user needs through real-time data processing and intelligent automation (Lee et al., 2019).

2.2 Affective Computing Research

Picard introduced the concept of affective computing, which focuses on enabling machines to recognize and respond to human emotions (Picard 1997). Recent studies have shown that AI systems can detect emotions using facial expressions, voice tone, biometric signals, and sentiment analysis. Researchers have emphasized the growing importance of emotionally intelligent systems in healthcare, education, customer service, and as virtual assistants.

Advancements in deep learning and multimodal emotion recognition have further improved the accuracy of affective computing systems, making emotional AI a key component of future web technologies (Zeng et al. 2009).

2.3 AI–Human Interaction Studies

Human–AI interaction studies focus on improving the collaboration between humans and intelligent systems. Researchers have suggested that future AI systems should be more transparent, adaptive, and human-centered (Shneiderman, 2020). Recent studies in HCI have emphasized natural communication through voice, gestures, and contextual understanding.

AI-powered assistants, social robots, and smart applications demonstrate how intelligent systems are becoming increasingly interactive and supportive in everyday activities. These developments support the vision of Web 4.0 as a symbiotic human–machine ecosystem that enhances human capabilities.

2.4 Research Gaps

Despite these rapid advancements, several gaps remain in the existing literature. Most Web 3.0 and Web 4.0 research has focused on semantic technologies, AI, and infrastructure, while limited attention has been given to emotional intelligence and empathic interaction. In addition, there is a lack of unified frameworks integrating AI, the Internet of Things, blockchain, affective computing, and brain–computer interfaces within a single Web 4.0 ecosystem.

Furthermore, ethical issues such as privacy, emotional manipulation, AI bias, and digital inequality remain underexplored. Research on future web generations, such as Web 5.0 and Web 6.0, remains largely conceptual and lacks practical implementation models.

Therefore, this study aims to provide a broader conceptual understanding of Web 4.0 and beyond by focusing on emotional intelligence, human–machine symbiosis, and future technological challenges.

Web 4.0: Definition and Conceptual Foundations

Definition:

Web 4.0, often referred to as the Symbiotic Web or the Intelligent and Emotional Internet, is considered the fourth generation of the World Wide Web. Unlike Web 3.0, which emphasizes semantic understanding, decentralization, and linked data, Web 4.0 aims to establish a two-way symbiotic interaction between humans and machines.

It envisions a digital ecosystem in which the web is not only ubiquitous and intelligent but also context-aware, emotionally responsive, and autonomously adaptive. This phase of the Internet is powered by technologies such as artificial intelligence (AI), the Internet of Things (IoT), 5G/6G networks, blockchain, big data, augmented reality (AR), and virtual reality (VR).

In essence, Web 4.0 represents a shift from information-driven to intelligence-driven connectivity, creating an ecosystem in which machines act as proactive partners rather than as passive tools.

Characteristics of Web 4.0

3.1.1 Symbiotic Human–Machine Interaction

Users and machines communicate seamlessly using natural language, gestures, emotions, and brain–computer interfaces.

AI-powered digital companions can anticipate the needs of users and act proactively.

3.1.2 Ubiquitous and Always-Connected Environment

Every device, sensor, and application is interconnected through the Internet of Things (IoT) and high-speed networks (5G/6G).

Access to real-time data enables continuous availability of services across platforms.

Artificial Intelligence as the Core

AI and machine learning drive personalization, predictions, and decision-making.

Systems learn from user behavior and continuously evolve to improve their accuracy and relevance.

Emotionally Intelligent Internet

The web can detect, interpret, and respond to human emotions through voice, facial recognition, biometric signals and sentiment analysis.

Digital agents and services adapt to users' emotional states.

5 Immersive and Experiential Internet

Widespread use of AR, VR, and Metaverse platforms for real-life simulations.

It enhances experiences in education, healthcare, entertainment, and e-commerce.

Autonomous and Self-Operating Systems

Services such as autonomous vehicles, smart homes, and intelligent supply chains operate with minimal human intervention.

Decisions are made in real time using AI-driven analytics.

Hyper-Personalization of Services

Web 4.0 tailors services to individual preferences, needs, and contexts.

For example, a personalized healthcare system that monitors health data and provides early interventions.

Enhanced Trust, Security, and Privacy

It is built on blockchain and decentralized technologies for secure transactions, identity management, and data ownership.

It prioritizes transparency and ethical data use.

4. Applications of Web 4.0

4.1 Smart Assistants and Emotionally Aware AI

Examples include Siri, Alexa, Google Assistant, and ChatGPT, which have evolved into empathetic and context-aware assistants.

They do not just answer questions but can predict user needs, analyze the tone of voice, and provide proactive recommendations.

Self-driving cars (e.g., Tesla and Waymo) rely on real-time AI, IoT sensors, and big data to make split-second decisions.

Transportation systems in smart cities integrate AI-driven traffic control to reduce congestion.

AI-powered apps, such as Fitbit, Apple Health, and telemedicine platforms, detect early signs of illness using biometric data.

-Virtual doctors provide real-time diagnosis and personalized treatment plans.

Platforms such as Meta's Horizon Worlds, Roblox, and Decentral are examples of virtual social ecosystems.

-Education uses VR classrooms; retail offers AR try-ons (IKEA's AR app for furniture and Sephora's virtual makeup).

Devices such as Google Nest, Amazon Echo, and Philips Hue connect appliances and sensors to create intelligent living environments.

-Homes become self-regulating: temperature, lighting, and energy use are automatically adjusted.

AI-driven robo-advisors (Betterment, Wealth front) provide personalized financial planning.

Blockchain enables secure decentralized banking and smart contracts (Ethereum).

5. Current Trends Driving Web 4.0

Artificial Intelligence Everywhere

Generative AI (ChatGPT, Bard, Claude) is becoming an integral part of business, education, and healthcare.

AI copilots in Microsoft Office and Google Workspace show how Web 4.0 is integrated into daily work processes.

5G and 6G Connectivity

5G has already enabled low-latency streaming, smart cars, and IoT applications. The advent of 6G (expected around 2030) will accelerate real-time holographic communication and the development of digital twins.

Businesses, universities, and governments are experimenting with virtual offices, training programs, and simulations.

Trend: Blending the physical and digital worlds for work, entertainment, and commerce.

Emotion AI (Affective Computing)

Companies are developing AI that can read facial expressions, voice tones, and biometric signals.

For example, Affectiva (acquired by Smart Eye) is building systems that detect driver fatigue and stress.

5.2 Decentralization and Web3 Foundations Blockchain, NFTs, and decentralized apps (dApps) form the backbone for trust, transparency, and digital ownership. Governments are exploring Central Bank Digital Currencies (CBDCs) that are powered by blockchain.

5.3 Sustainability and Green AI

There is a trend towards eco-friendly digital systems, such as AI, that reduce energy consumption in smart cities.

Web 4.0 aligns with the global goal of sustainable digital transformation.

5.4 Human–Machine Symbiosis

Early experiments in brain–computer interfaces (BCI) by companies such as Neuralink have shown the possibility of direct communication between the human brain and the web. This trend defines the “symbiotic” vision of Web 4.0.

6. Core Technologies Driving Web 4.0

Web 4.0 is based on the integration of several cutting-edge technologies that enable intelligence, personalization, autonomy, and trust in the digital ecosystem. The following core technologies underpin the development of the Symbiotic Web:

• Role in Web 4.0: AI and ML serve as the central nervous system of Web 4.0, powering intelligent decision-making, personalization, and predictive capabilities. Through deep learning, reinforcement learning, and neural networks, AI systems can analyze vast datasets, recognize patterns, and respond in real time.

• Applications:

Personalized recommendations in e-commerce and streaming services.

Predictive healthcare (early disease detection and treatment optimization).

Autonomous vehicles and robotics.

Smart assistants that adapt to user behavior.

• Applications:

Smart cities with automated traffic management and energy-efficient infrastructure are essential.

Smart homes that self-regulate temperature, lighting, and security are also included in the IoT.

Industrial IoT (IIoT) for predictive maintenance and manufacturing optimization.

Wearable devices for real-time health and fitness monitoring.

• Role in Web 4.0: NLP enables seamless human–machine communication by allowing computers to understand, interpret, and generate human language. In Web 4.0, NLP has evolved to include contextual and emotional understanding, thereby enabling more natural and empathetic interactions.

• Applications:

Intelligent chatbots and virtual assistants (e.g., ChatGPT, Alexa and Siri).

Real-time translation and multilingual communication tools are also available for use.

Sentiment and emotion analyses in customer service and healthcare.

Accessibility features (speech-to-text and assistive technologies for the disabled).

• Applications:

Decentralized finance (DeFi) and smart contracts are also discussed.

Securing digital identities and authentication systems is crucial.

Supply chain transparency and provenance tracking.

Decentralized applications (dApps) and ownership of digital assets (NFTs) are also included.

• Role in Web 4.0: Edge computing reduces reliance on centralized data centers by bringing computation and storage closer to the point of data generation (e.g., IoT devices and autonomous cars). This enables real-time processing, reduced latency, and higher efficiency, which are essential for immersive and autonomous applications.

• Applications:

Real-time analytics in healthcare (wearables for the instant detection of heart irregularities).

Autonomous vehicles require millisecond decision-making.

Smart manufacturing with local data processing for quality control.

AR/VR applications that demand ultra-low-latency experiences.

7. Challenges and Risks of Web 4.0

Despite its transformative potential, Web 4.0 presents several technical, ethical, and social challenges that must be addressed to ensure its sustainable adoption. The major risks can be categorized into data privacy and AI ethics, infrastructure demands, and the digital divide.

• Concerns:

Web 4.0 relies on massive volumes of personal data collected using IoT sensors, wearables, smart assistants, and digital services. This raises the risks of data misuse, surveillance, and identity theft.

Emotion AI and NLP-driven systems can interpret mood, sentiment, and biometric data, leading to potential violations of psychological and privacy rights.

• AI Ethics Issues:

Algorithmic bias and discrimination in decision-making (e.g., healthcare diagnosis and recruitment tools).

Lack of transparency and accountability in AI models

The risk of autonomous systems making unethical decisions without human oversight.

• Examples:

Controversies Regarding Facial Recognition Technologies in Law Enforcement.

Concerns about AI-powered hiring tools discriminating against minority groups.

• Challenges: Web 4.0 applications depend on high-speed, low-latency networks (5G/6G), edge computing, and massive IoT integration.

Developing countries face difficulties in deploying such infrastructure owing to high costs, limited technical expertise, and inconsistent power supplies.

• Risks:

Without reliable infrastructure, real-time applications (autonomous vehicles, telemedicine, AR/VR) may fail, leading to safety risks for users.

The high energy demands of AI data centers, blockchains, and IoT networks contribute to environmental concerns.

• Examples:

Countries lacking widespread 5G coverage may be excluded from advanced Web 4.0 services.

Energy-intensive blockchain systems pose a challenge to sustainability.

• Concerns:

Web 4.0 risks widening the gap between digitally advanced societies and those with limited access to modern technologies.

Disparities exist not only between developed and developing nations but also among urban and rural areas, wealthy and low-income groups, and digitally literate and non-literate populations.

• Impacts:

Inequitable access to smart education, healthcare, and business opportunities; and

Potential exclusion of vulnerable groups from participating in the digital economy.

Risk of "technological colonialism," where a few tech giants dominate global access and innovation.

• Examples:

Urban centers benefit from smart city projects, whereas rural areas remain underdeveloped.

Limited affordability of AR/VR devices, wearables, and autonomous technologies in low-income households

8. Beyond Web 4.0

The Internet continues to evolve through successive stages, each marked by new forms of human–machine interactions. While Web 4.0 emphasizes intelligence, ubiquity, and emotional responsiveness, a speculative future suggests a deeper integration between human cognition and digital systems.

9. Discussion

• Definition: Web 5.0 is envisioned as the "Emotional Web," where the Internet not only processes information intelligently (Web 3.0) and symbiotically (Web 4.0), but also understands, interprets, and responds to human emotions in real time.

• Core Features:

Advanced Affective Computing (AI systems capable of reading emotions through facial recognition, voice tone, and biometric data).

Highly personalized and emotion-sensitive virtual assistants that adapt to users' mental and emotional states are required. o Integration of immersive technologies (AR/VR/metaverse) with emotional responsiveness for richer human experiences.

• Applications:

Mental health therapy using empathetic AI companions.

Emotion-driven marketing and entertainment.

Virtual teachers/tutors that adapt to student frustration or curiosity.

Web 6.0: Neural or Brain-Web Interface

• **Definition**:

Web 6.0 is envisioned as a Neural Web, enabling direct interaction between the human brain and the Internet through brain–Computer Interfaces (BCIs). This stage blurs the line between thoughts and digital actions.

• Core Features:

Neural implants or wearable neurotechnology for seamless mind-to-web connectivity.

Machines not only understand human emotions but also access human cognition, memory, and intentions.

The possibility of creating a shared collective intelligence, where multiple minds collaborate directly via the web.

• Applications:

Healthcare: Direct brain-to-computer communication for restoring mobility in patients with paralysis.

Education: Instant access to knowledge ("learning by downloading").

Work: Thought-driven interfaces for design, programming and creative production.

Communication: Telepathic-like communication through digital networks is possible.

• Trends and Vision:

The progression from symbiotic interaction (Web 4.0) to emotional intelligence (Web 5.0) and eventually neural integration (Web 6.0) represents a trajectory toward deep human–machine fusions.

Technologies such as Neuralink, brain-wave-controlled prosthetics, and immersive metaverse ecosystems are early steps toward this integration.

• Opportunities:

Enhanced human cognition, memory, and problem-solving through AI augmentation.

Creation of hybrid societies in which humans and intelligent systems collaborate seamlessly.

Expansion of digital identity and presence into multidimensional virtual realities.

• Challenges:

Ethical concerns: Should machines have access to human thoughts

Security risks: Hacking into brain–web connections could be catastrophic.

Philosophical questions: Redefining identity, consciousness, and humanity in a hyper-connected future.

10. Conclusion

10.1 Key Takeaways The evolution from Web 1.0 to Web 4.0 demonstrates a steady shift from static information delivery to intelligent, immersive, and symbiotic interactions between humans and machines. Web 4.0 represents a new era of ubiquitous connectivity, emotional intelligence, and autonomous decision-making supported by technologies such as AI, IoT, NLP, blockchain, and edge computing. Its applications span critical domains, including education, healthcare, business, smart cities, and media, with the potential to redefine how people live, learn, work, and interact in digital environments. However, this transformation is not without risks. Concerns regarding data privacy, AI ethics, infrastructure demands, and the digital divide highlight the importance of a balanced approach to technological advancement in the field.

10.2 Responsible Development of Web 4.0

For Web 4.0 to realize its potential, development must be responsible, inclusive, and ethical. The key considerations were as follows:

Privacy and Security: Ensuring that sensitive personal and emotional data are handled transparently and securely.

Ethical AI: Algorithms that are unbiased, explainable, and aligned with human values.

Sustainability: Designing infrastructure and technologies that minimize environmental impacts.

Equity and Inclusion: Bridging the digital divide so that the benefits of Web 4.0 reach all communities, including marginalized groups.

10.3 Future Research Directions

Role of Researchers, Developers, and Policymakers

• Researchers:

Advances in knowledge of AI, human–machine symbiosis, and affective computing.

Exploring the social, psychological, and cultural implications of Web 4.0 and beyond.

Propose frameworks for the ethical and sustainable adoption of AI.

• Developers and Innovators:

Design user-centered and emotionally intelligent technology.

Implement privacy-first, secure, and interoperable systems.

Responsible experimentation with emerging domains such as AR/VR, brain–computer interfaces, and autonomous systems.

• Policymakers and Regulators:

Legal frameworks and ethical standards governing the use of AI, IoT, and data should be established.

Ensuring fair digital access to reduce the global and local digital divides.

Support research, innovation, and education that foster the safe and equitable integration of Web 4.0 technologies.

References

[1] Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic web. Scientific American, 284(5), 34–43. https://doi.org/10.1038/scientificamerican0501-34
[2] Cowie, R., Douglas-Cowie, E., Tsapatsoulis, N., Votsis, G., Kollias, S., Fellenz, W., & Taylor, J. G. (2011). Emotion recognition in human-computer interaction. IEEE Signal Processing Magazine, 18(1), 32–80. https://doi.org/10.1109/79.911197
[3] Deloitte Insights. (2025). Tech trends 2025: The age of generative AI and beyond. https://www2.deloitte.com/insights
[4] Fuchs, C. (2017). Social media: A critical introduction (2nd ed.). Sage Publications.
[5] Gartner. (2019). Top 10 strategic technology trends for 2019: The intelligent digital mesh. Gartner Research.
[6] Hajkowicz, S., Bratanova, A., Newman, C., & Taylor, P. (2023). Artificial intelligence adoption in the physical sciences, natural sciences, life sciences, social sciences, and the arts and humanities: A bibliometric analysis of research publications from 1960 to 2021. AI and Society, 38(3), 119–140. https://doi.org/10.1007/s00146-023-01574-1
[7] Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of social media. Business Horizons, 53(1), 59–68. https://doi.org/10.1016/j.bushor.2009.09.003
[8] Kimmons, R., Veletsianos, G., & Hill, M. (2024). Trends and Topics in Educational Technology: 2024 Edition. EdTech Books. https://edtechbooks.org/
[9] Kimmons, R., Veletsianos, G., & Hill, M. (2025). Trends and topics in educational technology: 2025 edition. EdTech Books. https://edtechbooks.org/
[10] McKinsey & Company. (2025). Technology trends outlook 2025. https://www.mckinsey.com/capabilities/mckinsey-digital

[11] National Institutes of Health (NIH). (2025). NIH research matters. National Institutes of Health. https://www.nih.gov/news-events/nih-research-matters
[12] Nature. (2024). Science in 2025: Events to watch in the coming year. Nature News. https://www.nature.com/news
[13] O'Reilly, T. (2005). What is Web 2.0: Design patterns and business models for the next generation of software. O'Reilly Media. https://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html
[14] Peltonen, E., Ylianttila, M., Mämmelä, A., & Koucheryavy, Y. (2020). 6G white paper on edge intelligence. 6G Flagship. University of Oulu.
[15] Picard, R. W. (1997). Affective computing. MIT Press.
[16] Reuters. (2025). What does the latest science tell us about climate change? Reuters News. https://www.reuters.com
[17] Sestino, A., Prete, M. I., Piper, L., & Guido, G. (2020). Internet of Things and big data as enablers of servitization in B2B companies: A conceptual framework. Business Process Management Journal, 26(5), 1141–1157. https://doi.org/10.1108/BPMJ-11-2018-0382
[18] Tegmark, M. (2017). Life 3.0: Being human in the age of artificial intelligence. Alfred A. Knopf.
[19] Times of India. (2025). Did the pandemic age our brains? A new study reveals the "shocking" truth. The Times of India. https://timesofindia.indiatimes.com
[20] Yarosh, S. (2020). Human–AI symbiosis and the evolution of Web 4.0. Journal of Emerging Web Technologies, 5(2), 12–25.
[21] Ylianttila, M., Matinmikko-Blue, M., & Seppänen, V. (2020). 6G white paper: Research challenges for trust, security, and privacy. 6G Flagship. University of Oulu.
[22] Sahani, S. K., Lee, T.-F., Pandey, D., Pandey, B. K., Jha, R., & Karna, S. L. (2026). Machine learning–augmented hybrid risk management and deep uncertainty quantification in Nepalese management systems: Fractional stochasticity, Wasserstein robustness, and rough–path neural filtering. Journal of Intelligent Decision Making and Information Science, 3(3s), 1850–1873. https://doi.org/10.59543/jidmis.v3.971
[23] Sahani, S. K., Lee, T.-F., Pandey, D., Pandey, B. K., & Mandal, K. (2026). Hybrid analytical, numerical, and machine learning frameworks for solving deterministic and stochastic differential equations with stability, convergence, and uncertainty quantification. Journal of Intelligent Decision Making and Information Science, 3(3s), 1794–1849. https://doi.org/10.59543/jidmis.v3.970
[24] Sahani, S. K., Lee, T.-F., Pandey, D., Pandey, B. K., Sah, B. K., & Jha, R. (2026). Hybrid analytical, numerical and machine learning approaches on decision-making, risk management, operational stability, and uncertainty analysis in Nepalese management systems. Journal of Intelligent Decision Making and Information Science, 3(3s), 1772–1793. https://doi.org/10.59543/jidmis.v3.969
[25] Sahani, S. K., Lee, T.-F., Pandey, D., Pandey, B. K., Sah, B. K., Jha, R., & Sah, D. K. (2026). Hybrid analytical–numerical–machine learning architectures for decision-making, risk management, operational stability, and uncertainty quantification in dental practice management systems: A mathematical theory. European Journal of Prosthodontics and Restorative Dentistry, 34(5s), 298–313. https://doi.org/10.1922/ejprd.v34i5s.1559
[26] Sahani, S. K., Lee, T.-F., Pandey, D., Pandey, B. K., Sah, B. K., Mandal, K., & Jha, R. (2026). Biotechnological catalysts in hybrid analytical–numerical–machine learning architectures for risk-aware decision-making and uncertainty quantification in Nepalese management systems. European Journal of Prosthodontics and Restorative Dentistry, 34(7s), 332–350. https://doi.org/10.1922/ejprd.v34i7s.1622
[27] Sahani, S. K., Lee, T.-F., Pandey, D., Pandey, B. K., Sah, B. K., & Jha, R. (2026). A hybrid analytical, numerical, and machine learning framework for health management, resource allocation, operational efficiency, risk forecasting, and strategic decision-making in Nepal. International Journal of Computer Information Systems and Industrial Management Applications, 18(9s), 1221–1242. https://doi.org/10.70917/ijcisim-2026-3400