

Applying eXtended Reality(XR) Technology in Commerce, Management, and Business Applications: A Survey

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Abstract—This survey paper provides an in-depth survey of the application of eXtended Reality (XR) technology in the fields of commerce, management, and business edutainment. XR is a collective term that encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), and it is poised to transform how businesses operate, engage with consumers, and educate their employees. This survey examines the current state of XR technology in these areas, highlighting its impact, challenges, and future potential. It explores case studies and real-world applications, revealing the diverse ways in which XR is being utilized in commerce, management, and business edutainment.

Keywords— *Computer Graphics, Virtual Reality, Survey*

I. INTRODUCTION

In a world propelled by rapid technological advancements, XR technology stands at the forefront of innovation and is applicable to various industries. Based on the UK data statistics Figure 1, education is the important aspect[31], followed by the medical domain [3], retail, aerospace[1], and construction [2]. Today, this survey aims to provide a comprehensive overview of how XR is being harnessed in commerce, management, and business edutainment, offering insights into its diverse applications, challenges, and transformative potential. It holds the promise of enhanced immersive experiences and novel avenues for growth [4]. Delving into the current landscape, trends, challenges, and prospects aims to provide a holistic understanding of how XR transforms these domains. Through an in-depth analysis of case studies, best practices, and emerging opportunities, the insights gained will help organizations make informed decisions regarding XR adoption and implementation and how XR can be effectively harnessed for organizations become crucial for staying competitive and innovative. While this survey strives to offer a comprehensive overview, it is essential to acknowledge the inherent limitations. The scope encompasses XR's applications, from retail experiences to strategic decision-making and educational gamification. However, the rapidly evolving nature of XR technology and the diverse business contexts it affects may result in some respects receiving more emphasis than others. Additionally, the survey may not encompass all possible challenges, advancements, or nuances in XR landscape due to the dynamic nature of the field.

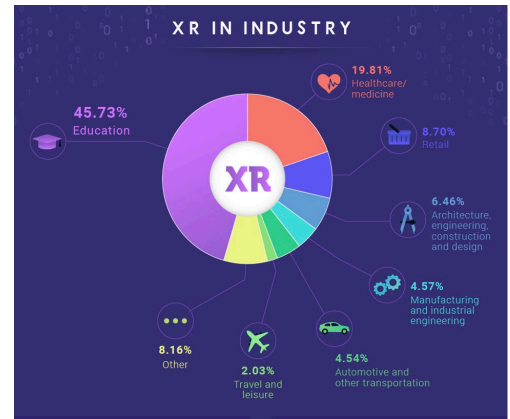


Figure 1: XR in industry

II. OVERVIEW

XR technology [53] has undergone remarkable evolution from its conceptual roots to today's sophisticated applications. The advent of powerful computing and advancements in graphics capabilities have propelled XR to new heights, making it accessible to various industries that will be used across industries. XR refers to an immersive digital environment that blends physical and virtual realities, encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) [26], as shown in Figure 2 [5]. VR immerses users entirely in a virtual world [53-60], AR overlays digital elements onto the real world [12][47-52], and MR merges both to interact with digital content in real-time [13][23][61].

Individual users tend to use VR and AR, and MR is mainly used by large companies [30]. XR experiences are powered by a combination of VR, AR, and MR hardware and software [5]. The hardware includes devices like VR headsets, AR glasses, and handheld controllers [27]. There's impressive innovation in the hardware that supports XR experiences, whether it's high-end headsets that require a powerful computer to run them or low-end headsets that are stand-alone devices in Figure 3 [29]. For example, Oculus Quest for business is the first standalone headset made by Facebook to have the same full tracking capabilities as high-end headsets that are available with 6DOF tracking on the head and hands; Microsoft HoloLens is an MR technology for business mainly used by frontline workers to

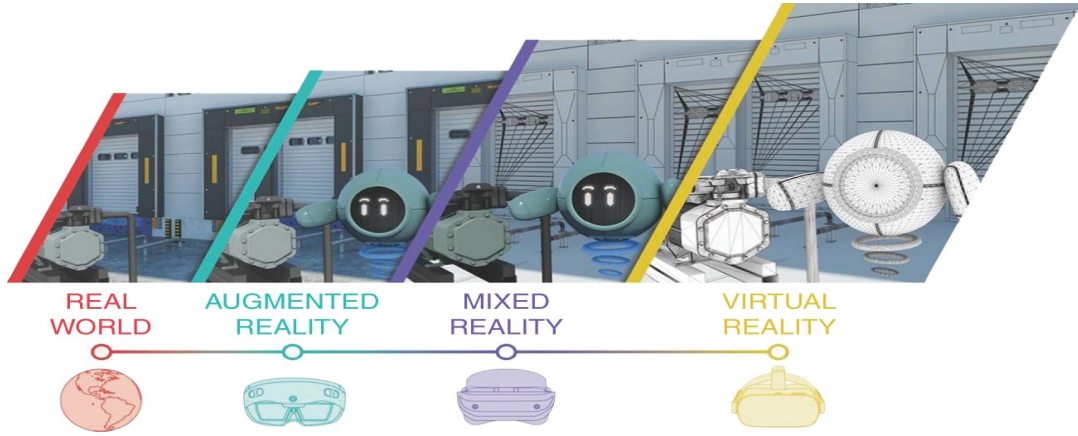


Figure 2: Computer-generated immersive environments

solve real business problems and deliver immediate ROI through intelligent apps with a solid case library [28]. The synergy between well-designed hardware and software is pivotal in delivering seamless and immersive XR experiences. Currently, XR software includes content creation platforms (open-source platforms and commercial software [30]), development tools, and XR-specific applications. Open-source platforms like Unity3D require familiarity with programming [34]. Yet commercial software is easy to use, such as Vuforia Studio for AR [35], Attensi [36], and Dimension 10 Studio [37].

III. APPLICATIONS IN COMMERCE

One of the most captivating applications of XR lies in its ability to revolutionize commerce. Virtual shopping experiences, for instance, offer consumers a unique blend of convenience and engagement, enabling them to explore products in digital spaces before making purchase decisions as shown in Figure 4 [6]. This spatial computing also facilitates product visualization and customization, allowing customers to interact with and personalize products in real time. The immersive shopping experience bridges the gap between online and in-store shopping, enhancing consumer engagement and reducing purchase uncertainty. In addition, Marketers are leveraging XR to create captivating and memorable campaigns with marketing strategies [7][9]. AR-powered advertisements enable users to interact with products and engage with brands in novel ways[11]. Amazon’s smart home gadgets – Echo Frames [8]; Tech companies like Meta, and Microsoft are investing heavily in emerging future internet models [10]. This immersive engagement enhances brand recognition and customer loyalty, also leading to building stronger relationships and boosting customer satisfaction. Furthermore, XR technology has extended its influence on supply chain and logistics management through immersive simulations and data visualization [40] based on mobile-based AR [45]. It can optimize processes that are inventory management (product visualization and identification and order picking[42]), warehouse layout planning, and distribution to reduce process complexity[41], as shown in Figure 5 [5]. AR visualization



Figure 5: Tracking operation support.

drives modern supply chain innovation and increases profits, reducing costs and carbon impact for enterprises like DHL logistics company [42].

IV. APPLICATIONS IN MANAGEMENT

In the realm of management, XR has become a game-changer by introducing innovative approaches to decision-making and team dynamics. XR transforms the way businesses interpret data by creating dynamic, immersive visualizations. Complex datasets are presented in three-dimensional space, offering deeper insights to managers, aiding in trend analysis, and identifying patterns that might be missed in traditional 2D representations. Through a centralized database, managers can explore various scenarios, test strategies, and evaluate potential outcomes in a controlled environment [46]. This empowers informed decision-making and strategic planning, reducing risks associated with uncertainty [44]. Moreover, remote collaboration and communication have been transformed, as XR provides seamless platforms for teams to interact in shared virtual environments, transcending geographical constraints [12]. It also fosters team building, collaborative environments, and leadership development to enhance project planning and tracking. For example, bringing employees from product development, research, sales, and marketing teams together to network and share ideas [32].

V. APPLICATIONS IN BUSINESS EDUTAINMENT

XR breathes life into learning experiences, engaging participants through gamification, interactive workshops, and simulations, as shown in Figure 6 [31]. Upskilling the workforce to harness the full potential of XR demands attention to bridge the knowledge gap. It would progressively train a skilled, motivated, and efficient workforce from onboarding and orientation, ready to meet the challenges of today's ever-evolving business landscape. Gamified learning environments [14] would motivate new team members to start taking virtual tours of company facilities, meet colleagues through avatars, and learn about company culture and policies in a truly memorable way. Furthermore, XR is invaluable for technical and job-specific training, enabling employees to hone their skills in a safe virtual environment before applying them in real-world scenarios [41]. Soft skills development, such as communication and leadership, also benefits from XR, with interactive scenarios and role-playing offering employees a platform to practice and improve [15]. Design targeted training programs based on employees' gaps or work roles will increase the effectiveness of training and improve their productivity based on the VR applications [16]. Safety training takes on a new dimension, as employees can experience emergency situations and practice safety procedures without any real-world risks. Sales and product training become more engaging and interactive, allowing sales teams to conduct immersive product demonstrations and practice sales scenarios within virtual spaces [13]. Customer service training can also benefit, offering employees the chance to fine-tune their customer interaction skills in realistic virtual settings [45]. Leadership development, team building, continuous learning, and language and cultural training will all find enhanced applications in XR [13]. This innovative technology also facilitates remote training, compliance training, and feedback and assessment, ensuring employees continually learn and grow, regardless of location.

VI. CHALLENGES AND CONSIDERATIONS

Despite progress, XR hardware still faces challenges, ranging from hardware capabilities to network infrastructure, and technical limitations that can impact immersive experience quality and user comfort. Performance and functional evaluation of virtual reality headsets depend on weight, field of view (FOV) [26], resolution [44], and storage parameters [30]. High-end headsets and standalone VR headsets need to consider computer specifications and parameters such as processor (Intel), RAM, integrated graphics, and internal storage respectively [24]. Moreover, based on the DHL experience [42], AR glasses cannot function normally during the entire shift without backup batteries or timely charging. If the headset is smaller and lighter and the longer the use time, user-friendliness would be higher [43]. Besides, the network foundation of XR relies on the capabilities of modern connections (wireless network bandwidth and 5G infrastructure [32]), which may cause connection delays and hinder transactions. But, in the future, the research and development of 6G wireless provides high data rate, low latency, and highly reliable wireless connection support to promote the comprehensive development and application of XR technology [39]. Content development poses another hurdle. For instance,

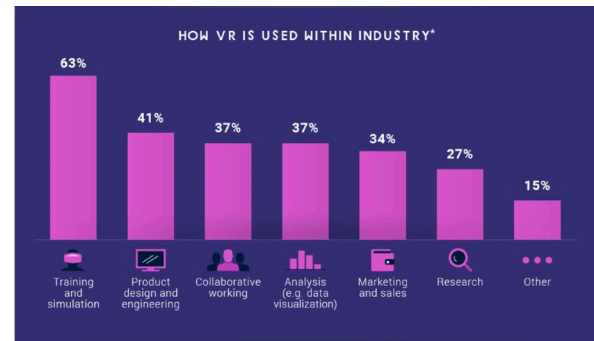


Figure 6: The proportion of VR in various industries

Poorly designed interfaces can lead to confusion and frustration, hindering the adoption of XR technology. It is important that creating intuitive and user-friendly XR experiences requires thoughtful cross-platform interface design [19] to intelligently manage the random dynamics of projects [46]. Its design could consider nine elemental aspects: comfort and safety, interaction, environment, spatial components, sensory input, engagement, constraints, inclusion, diversity, and accessibility [12].

Ethical and privacy concerns [19] arise as XR blurs the boundaries between reality and virtuality and uncertainty about new technology, raising questions about data security and user consent. From the risk management view of firms, security breaches in XR systems can have serious consequences. If an attacker gains access to the XR environment, they may have access to sensitive user data or even control over the XR hardware, which could lead to privacy violations, major data leakages, or other security risks [18]. Firms' daily operations need to include safety checks and necessary measures and train employees and users in the correct process [5]. Moreover, the immersive nature of XR experiences can make it challenging for users to understand the extent of data collection and how their personal information is being used. When firms design consent mechanisms, they could mitigate privacy concerns by updating measures of customer privacy concerns from three AR dimensions (unwanted social/economic exposure, reality perception bias, contextualized marketing) [18] and providing effective promises, e.g., not for marketing purposes [22].

VII. FUTURE TRENDS AND OPPORTUNITIES

As the technology evolves and XR technology is seen as a cornerstone of Industry 4.0 [30], business, management, and business edutainment possibilities continue to expand. Ongoing innovations in XR hardware and software are poised to enhance the fidelity, interactivity, and accessibility of XR experiences. The synergy between XR, Artificial Intelligence (AI), and the Internet of Things (IoT) holds the promise of creating intelligent, context-aware immersive environments to optimize efficiency in the next chapter of Industry and digital transformation (Figure 6) [17][33]. XR's potential to reshape business models is yet to be fully realized, with emerging markets and industries presenting uncharted territories for XR integration and innovation. Firms could explore novel product design, prototyping, and ideation ways to deliver specific products and

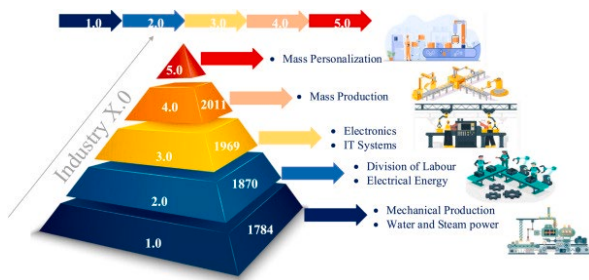


Figure 7: Industrial Evolution

services to each customer [33]. For example, development teams could develop XR technology that everyone uses without having to wear it on their bodies as societal XR [21].

VIII. CONCLUSION

XR technology presents promising opportunities for transforming commerce, management, and business education. The convergence of XR technology with these domains opens up new avenues for innovation, and this survey serves as a stepping stone for researchers, practitioners, and educators seeking to harness the power of XR for transformative business and educational experiences. However, successful implementation requires addressing technical, ethical, and financial challenges. As XR continues to evolve, businesses and educational institutions will explore its potential to enhance engagement, improve learning outcomes, and drive innovation.

REFERENCES

- [1] N. McHenry et al., "Predictive XR Telepresence for Robotic Operations in Space," 2021 IEEE Aerospace Conference (50100), Big Sky, MT, USA, 2021, pp. 1-10, doi: 10.1109/AERO50100.2021.9438161.
- [2] Zoleykani, M.J., Abbasianjahromi, H., Banihashemi, S., Tabadkani, S.A. and Hajirasouli, A. (2023), "Extended reality (XR) technologies in the construction safety: systematic review and analysis", *Construction Innovation*, Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/CI-05-2022-0131>
- [3] Andrews, C., Southworth, M.K., Silva, J.N.A. et al. Extended Reality in Medical Practice. *Curr Treat Options Cardio Med* 21, 18 (2019). <https://doi.org/10.1007/s11936-019-0722-7>
- [4] Kenwright, B. (2020). The future of extended reality (xr). *Communication Article*. January.
- [5] Stanney, Nye, H., Haddad, S., Hale, K. S., Padron, C. K., & Cohn, J. V. (2021). EXTENDED REALITY (XR) ENVIRONMENTS. In *HANDBOOK OF HUMAN FACTORS AND ERGONOMICS* (pp. 782–815). John Wiley & Sons, Inc. <https://doi.org/10.1002/9781119636113.ch30>
- [6] Atiker, B. (2023). The Conceptual Design Framework for XR Marketing. In: Martins, N., Raposo, D. (eds) *Communication Design and Branding*. Springer Series in Design and Innovation, vol 32. Springer, Cham. https://doi.org/10.1007/978-3-031-35385-7_19
- [7] (MBA), O. K. (n.d.). The Future of Marketing: How XR Technology is transforming the customer experience. *LinkedIn*. <https://www.linkedin.com/pulse/future-marketing-how-xr-technology-transforming-olga-krivchenko/>
- [8] Bohn, D. (2020, December 24). Amazon Echo Frames Review: Listen to these Specs. *The Verge*. <https://www.theverge.com/22197463/amazon-echo-frames-review-alexa>
- [9] Alcañiz, M., Bigné, E., & Guixeres, J. (2019, June 17). Virtual reality in marketing: A Framework, review, and research agenda. *Frontiers*. <https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01530/full>
- [10] Kraus, S., Kanbach, D.K., Krysta, P.M., Steinhoff, M.M., Tomini, N.: Facebook and the creation of the metaverse: radical business model innovation or incremental transformation? *Int. J. Entrep. Behav. Res.* 28, 52–77 (2022). <https://doi.org/10.1108/IJEBR-12-2021-0984>
- [11] Philipp A. Rauschnabel, Barry J. Babin, M. Claudia tom Dieck, Nina Krey, Timothy Jung. What is augmented reality marketing? Its definition, complexity, and future. *Journal of Business Research*, Volume 142, 2022, Pages 1140-1150, ISSN 0148-2963, <https://www.sciencedirect.com/science/article/pii/S0148296321010043>
- [12] Hillmann, C. (2021). The History and Future of XR. In: *UX for XR. Design Thinking*. Apress, Berkeley, CA. https://doi.org/10.1007/978-1-4842-7020-2_2
- [13] F. Palmas, P. F. J. Niemann, D. A. Plecher and G. Klinker, "Extended Reality Training for Business and Education: The New Generation of Learning Experiences," 2022 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), Singapore, Singapore, 2022, pp. 322-326, doi: 10.1109/ISMAR-Adjunct57072.2022.00071.
- [14] W. N. Hidayat, S. Patmanthara, S. M. Tosepu, T. A. Sutikno and R. Wakhidah, "Gamified Mobile Learning For Digital Business Model Course," 2021 3rd International Conference on Research and Academic Community Services (ICRACOS), Surabaya, Indonesia, 2021, pp. 290-295, doi: 10.1109/ICRACOS53680.2021.9702057.
- [15] F. Palmas, R. Reinelt, J. E. Cichor, D. A. Plecher and G. Klinker, "Virtual Reality Public Speaking Training: Experimental Evaluation of Direct Feedback Technology Acceptance," 2021 IEEE Virtual Reality and 3D User Interfaces (VR), Lisboa, Portugal, 2021, pp. 463-472, doi: 10.1109/VR50410.2021.00070.
- [16] Homer, M. (2001), "Skills and competency management", *Industrial and Commercial Training*, Vol. 33 No. 2, pp. 59-62. <https://doi.org/10.1108/00197850110385624>
- [17] Philipp A. Rauschnabel, Reto Felix, Chris Hinsch, Hamza Shahab, Florian Alt.(2022).What is XR? Towards a Framework for Augmented and Virtual Reality. *Computers in Human Behavior*, Volume 133, 2022, 107289, ISSN 0747-5632, <https://www.sciencedirect.com/science/article/pii/S074756322200111X>
- [18] Lammerding, L., Hilken, T., Mahr, D., Heller, J. (2021). Too Real for Comfort: Measuring Consumers' Augmented Reality Information Privacy Concerns. In: tom Dieck, M.C., Jung, T.H., Loureiro, S.M.C. (eds) *Augmented Reality and Virtual Reality. Progress in IS*. Springer, Cham. https://doi.org/10.1007/978-3-030-68086-2_8
- [19] Cowan, K., Javornik, A., Jiang, P. Privacy concerns when using augmented reality. *wiley online library*. (2021). <https://onlinelibrary.wiley.com/doi/abs/10.1002/mar.21576>
- [20] Gonshe, I., Feng, P., McArm, T., Christenson, A. (2023). Designing for Wide Adoption: An Inexpensive and Accessible Extended Reality (XR) Device. In: Stephanidis, C., Antona, M., Ntoa, S., Salvendy, G. (eds) *HCI International 2023 Posters*. HCI 2023. Communications in Computer and Information Science, vol 1836. Springer, Cham. https://doi.org/10.1007/978-3-031-36004-6_25
- [21] Görlich, D. (2022). Societal XR—A Vision Paper. *ParadigmPlus*, 3(2), 1-10. <https://doi.org/10.55969/paradigmplus.v3n2a1>
- [22] Abraham Hani Mhaidli and Florian Schaub. 2021. Identifying Manipulative Advertising Techniques in XR Through Scenario Construction. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 296, 1–18. <https://doi.org/10.1145/3411764.3445253>
- [23] F. Palmas and G. Klinker, "Defining Extended Reality Training: A Long-Term Definition for All Industries," 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), Tartu, Estonia, 2020, pp. 322-324, doi: 10.1109/ICALT49669.2020.00103.
- [24] Gironacci, I. M. (1970, January 1). State of the art of extended reality tools and applications in business. IGI Global. <https://www.igi-global.com/chapter/state-of-the-art-of-extended-reality-tools-and-applications-in-business/260607>
- [25] Y. Vermeulen, S. Van Damme, G. Van Wallendael, F. De Turck and M. T. Vega, "Haptic Interactions for Extended Reality," 2023 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2023, pp. 1-6, doi: 10.1109/ICCE56470.2023.10043499.

- [26] The ultimate VR, AR, Mr Guide. Aniwa. (2021, August 6). <https://www.aniwa.com/guide/vr-ar/ultimate-vr-ar-mr-guide/>
- [27] Learning Design & Technology. Extended Reality (XR) Tools | Learning Design & Technology. (n.d.). <https://learningdesign.as.virginia.edu/tools/extended-reality-xr-tools>
- [28] Xalter. (2022, April 2). XR hardware platforms – the Pros & Cons. <https://www.xalter.com/xr-hardware-platforms-the-pros-cons/>
- [29] Buy hololens 2: Find specs, features, capabilities & more. Microsoft Store. (n.d.). <https://www.microsoft.com/en-us/d/hololens-2/91pnzznzwcp?activetab=pivot%3Aoverviewtab>
- [30] Husár, J., Knapčíková, L., Trojanowska, J. (2023). Study of Hardware and Software Resources for Mobile Applications of Immersive Technologies in Manufacturing. In: Afonso, J.L., Monteiro, V., Pinto, J.G. (eds) Sustainable Energy for Smart Cities. SESC 2022. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 502. Springer, Cham. https://doi.org/10.1007/978-3-031-33979-0_3
- [31] What is XR and future of XR: Hire Intelligence. Hire Intelligence AU. (2023, May 25). <https://www.hire-intelligence.co.uk/the-future-of-xr/>
- [32] LINK, J. (2023, September 14). What is XR, and how is it radically transforming industries?. Autodesk. <https://www.autodesk.com/design-make/articles/what-is-xr>
- [33] Praveen Kumar Reddy Maddikunta, QuocViet Pham, Prabadevi B, N Deepa, Kapil Dev, Thippa Reddy Gadekallu, Rukhsana Ruby, Madhusanka Liyanage. Industry 5.0: A survey on enabling technologies and potential applications. Journal of Industrial Information Integration. Volume 26, 2022, 100257, ISSN 2452-414X. <https://www.sciencedirect.com/science/article/pii/S2452414X21000558>
- [34] Mohamed Suleum Salim Al Hamzy, Shijin Zhang, Hong Huang, and Wanwan Li. 2023. Creative NFT-Copyrighted AR Face Mask Authoring Using Unity3D Editor. In Proceedings of the 2023 7th International Conference on E-Commerce, E-Business and E-Government (ICEEG '23). Association for Computing Machinery, New York, NY, USA, 174–180. <https://doi.org/10.1145/3599609.3599635>
- [35] J. Kašćak, M. Telišková, J. Török, P. Baron, J. Zajac and J. Husár, "Implementation of Augmented Reality into the Training and Educational Process in Order to Support Spatial Perception in Technical Documentation," 2019 IEEE 6th International Conference on Industrial Engineering and Applications (ICIEA), Tokyo, Japan, 2019, pp. 583-587, doi: 10.1109/IEA.2019.8715120.
- [36] Gamified simulation training. Attensi. (2023, July 7). <https://attensi.com/>
- [37] Deloitte Launches Unlimited Reality Services – Press Release. Deloitte United States. (2023, February 22). <https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/deloitte-launches-unlimited-reality-services.html>
- [38] A. Fuchs, S. Appel and P. Grimm, "Immersive Spaces for Creativity: Smart Working Environments," 2023 International Electronics Symposium (IES), Denpasar, Indonesia, 2023, pp. 610-617, doi: 10.1109/IES59143.2023.10242458.
- [39] M. Z. Chowdhury, M. Shahjalal, S. Ahmed and Y. M. Jang, "6G Wireless Communication Systems: Applications, Requirements, Technologies, Challenges, and Research Directions," in IEEE Open Journal of the Communications Society, vol. 1, pp. 957-975, 2020, doi: 10.1109/OJCOMS.2020.3010270.
- [40] Büyüközkan, G. (2023). Metaverse and Supply Chain Management Applications. In: Esen, F.S., Tinmaz, H., Singh, M. (eds) Metaverse. Studies in Big Data, vol 133. Springer, Singapore. https://doi.org/10.1007/978-981-99-4641-9_26
- [41] Rejeb, A., Keogh, J.G., Wamba, S.F. et al. The potentials of augmented reality in supply chain management: a state-of-the-art review. Manag Rev Q 71, 819–856 (2021). <https://doi.org/10.1007/s11301-020-00201-w>
- [42] Role of XR wearables in intralogistics field - theseus. (n.d.-b). https://www.theseus.fi/bitstream/handle/10024/215481/kristina_matveiu_k_thesis.pdf?sequence=2
- [43] Marr, B. (2021). Extended reality in practice: 100+ amazing ways virtual, augmented and mixed reality are changing business and Society. Wiley.
- [44] Helmold, M. (2023). Extended Reality (XR) in QM. In: Virtual and Innovative Quality Management Across the Value Chain. Management for Professionals. Springer, Cham. https://doi.org/10.1007/978-3-031-30089-9_3
- [45] Zwoliński G, Kamińska D, Laska-Leśniewicz A, Haamer RE, Vairinhos M, Raposo R, Urem F, Reisinho P. Extended Reality in Education and Training: Case Studies in Management Education. Electronics. 2022; 11(3):336. <https://doi.org/10.3390/electronics11030336>
- [46] Khatib, M. E., Alhosani, A., Alhosani, I., Matrooshi, O. A., & Salami, M. (2022, April 8). Simulation in project and Program Management Utilization, challenges and opportunities. SCIRP. <https://www.scirp.org/journal/paperinformation.aspx?paperid=116938>
- [47] Bui, D., Li, W. and Huang, H., 2023. CarGameAR: An Integrated AR Car Game Authoring Interface for Custom-Built Car Programed on Arduino Board. International Conference on Graphics and Signal Processing (ICGSP 2023)
- [48] V. B. Gholap and W. Li, 2023. "Past, Present, and Future of the Augmented Reality (AR)-Enhanced Interactive Techniques: A Survey," 2023 7th International Conference on Machine Vision and Information Technology (CMVIT), Xiamen, China, 2023, pp. 143-148, doi: 10.1109/CMVIT57620.2023.00035.
- [49] Choi G, Li W. Prevailing Technologies Augmented Reality Software with Hardware for E-Entertainment and E-Learning Purposes: A Survey. InProceedings of the 9th International Conference on Education and Training Technologies 2023 Apr 21 (pp. 1-7).
- [50] Li W. Simulating Quantum Turing Machine in Augmented Reality. InProceedings of the 2023 8th International Conference on Multimedia and Image Processing 2023 Apr 21 (pp. 107-112).
- [51] Li W. Simulating Turing Machine in Augmented Reality. In2022 International Conference on Computational Science and Computational Intelligence (CSCI) 2022 Dec 14 (pp. 2015-2022). IEEE.
- [52] W Li. 2023. Simulating Virtual Environment and Experience for Training, Exergaming, and Edutainment in eXtended Reality (XR): A Survey. International Conference on Computer Application Technology (CCAT 2023), IEEE.
- [53] Li, W., Esmaeili, B. and Yu, L.F., 2022, March. Simulating Wind Tower Construction Process for Virtual Construction Safety Training and Active Learning. In 2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) (pp. 369-372). IEEE.
- [54] W. Li, "Simulating Ice Skating Experience in Virtual Reality," 2022 7th International Conference on Image, Vision and Computing (ICIVC), Xi'an, China, 2022, pp. 706-712, doi: 10.1109/ICIVC55077.2022.9887260.
- [55] W. Li, "Procedural Marine Landscape Synthesis for Swimming Exergame in Virtual Reality," 2022 IEEE Games, Entertainment, Media Conference (GEM), St. Michael, Barbados, 2022, pp. 1-8, doi: 10.1109/GEM56474.2022.10017505.
- [56] Li, W., 2023, March. Terrain synthesis for treadmill exergaming in virtual reality. In 2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) (pp. 263-269). IEEE.
- [57] W. Li, 2023. Animating Parametric Kinetic Spinner in Virtual Reality. In 2023 7th International Conference on Advances in Image Processing (ICAIP 2023), November 17--19, 2023, Beijing, China. ACM, New York, NY, USA 5 Pages.
- [58] Li, W., 2023. InsectVR: Simulating Crawling Insects in Virtual Reality for Biology Edutainment. In Proceedings of the 7th International Conference on Education and Multimedia Technology (ICEMT '23). Association for Computing Machinery, New York, NY, USA, 8–14. <https://doi.org/10.1145/3625704.3625757>
- [59] Li, W., 2023, March. Elliptical4VR: An Interactive Exergame Authoring Tool for Personalized Elliptical Workout Experience in VR. In Proceedings of the 2023 5th International Conference on Image, Video and Signal Processing (pp. 111-116).
- [60] W. Li, "SurfChessVR: Deploying Chess Game on Parametric Surface in Virtual Reality," 2023 9th International Conference on Virtual Reality (ICVR), Xianyang, China, 2023, pp. 171-178, doi: 10.1109/ICVR57957.2023.10169609.
- [61] Kim DJ, Li W. A View Direction-Driven Approach for Automatic Room Mapping in Mixed Reality. InProceedings of the 2023 5th International Conference on Image Processing and Machine Vision 2023 Jan 13 (pp. 29-33).