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Human-AI in Digital Media: Effects on Digital Twins and the Moderating Role of Personalized Advertising

Jun Cui[1]

[1] Solbridge International School of Business, Woosong University, Daejeon, Republic of Korea

Correspondence: Jun Cui, Solbridge International School of Business, Woosong University, Daejeon, Republic of Korea. E-mail: jcui228@student.solbridge.ac.kr

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Abstract

Digital media technology has revolutionized various industries, particularly through its integration with digital twin (DT) technology. A digital twin is a dynamic virtual model of a physical object, system, or process that enables real-time simulation, optimization, and data-driven decision-making. This study investigates the impact of digital media technology on digital twins, with a specific focus on the moderating role of Human-AI-driven personalized advertising. Adopting a qualitative research approach, this study utilizes semi-structured interviews with industry experts and case study analyses of companies leveraging digital twins. Grounded in the Technology Acceptance Model (TAM) and Media Richness Theory (MRT), the findings reveal that digital media technology, enhanced by Human-AI innovation, improves digital twins by increasing interactivity, real-time data transmission, and user engagement. Moreover, Human-AI-driven personalized advertising strengthens this relationship by fostering deeper consumer engagement, enhancing brand loyalty, and enabling real-time customization in digital twin ecosystems. This study offers both theoretical and practical contributions by bridging digital media technology, digital twins, Human-AI innovation, and marketing personalization strategies.

Keywords: digital media technology, Digital Twin (DT), Human-AI Innovation, personalized advertising, brand loyalty, data-driven decision-making, marketing personalization, interactivity, real-time data transmission

1. Introduction

The rapid evolution of digital media technology, coupled with Human-AI innovation, has transformed industries by enabling more immersive, data-driven, and interactive experiences. One of the most promising applications of this transformation is the integration of digital twin (DT) technology—virtual replicas of physical objects, systems, or processes that allow real-time monitoring, analysis, and optimization. Digital twins have been widely adopted in industries such as manufacturing, healthcare, urban planning, and smart cities, driving efficiency and informed decision-making. As AI, big data analytics, and the Internet of Things (IoT) continue to converge, digital twins are becoming increasingly sophisticated, enabling organizations to simulate and optimize complex operations in real time. However, while digital media technology has significantly enhanced digital twin functionality, the potential role of Human-AI-driven personalized advertising in this ecosystem remains underexplored.

At the same time, Human-AI-powered personalized advertising has revolutionized digital marketing by leveraging AI algorithms and real-time consumer data to deliver tailored marketing experiences. This approach, widely implemented in e-commerce, social media, and digital marketplaces, enhances user engagement and improves conversion rates by aligning advertising content with individual preferences and behaviors. However, despite the increasing adoption of both digital twins and AI-driven personalized advertising, little research has examined their intersection. Understanding how personalized advertising moderates the impact of digital media technology on digital twins could offer valuable insights for both academia and industry. Specifically, AI-driven marketing strategies within digital twin environments have the potential to enhance consumer interaction, increase brand loyalty, and refine real-time customization, yet these dynamics remain largely unstudied.

This study makes several notable contributions to the intersection of digital twin technology, digital marketing, and personalized consumer engagement, advancing the existing literature in meaningful ways. First, it expands the theoretical framework by integrating two well-established models: the Technology Acceptance Model (TAM) and Media Richness Theory (MRT). While digital twins have predominantly been explored within manufacturing, healthcare, and smart city contexts, this research applies them to the field of digital marketing, thus broadening their potential applications. By exploring how digital twin technology can foster personalized, real-time consumer

engagement, the study demonstrates that the technology's effectiveness is not only tied to its technical capabilities but also to its ability to offer immersive, dynamic experiences that appeal to users' individual preferences. This integration of TAM and MRT highlights the critical role of richer media in enhancing communication and engagement, affirming the idea that more interactive, visually rich platforms—such as those enabled by digital twins—are more likely to be adopted and leveraged effectively by users. The study thus paves the way for further research on how digital twin technology can be applied in innovative ways beyond traditional industrial settings, emphasizing its potential as a key player in personalized marketing.

In addition to expanding the theoretical application of TAM and MRT, the research introduces the concept of personalized advertising as a moderator of digital twin adoption, offering a novel contribution to the field of technology acceptance. While TAM traditionally emphasizes perceived ease of use and usefulness as core drivers of technology adoption, this study shows that the personalization of advertising content significantly enhances the perceived relevance and value of digital twin experiences. This finding shifts the focus from purely technological aspects to the role of personalized content in shaping consumer attitudes and engagement with digital technologies. By demonstrating that advertising personalization can improve user perceptions and engagement within digital twin environments, the research extends TAM's applicability, showing that user experience is shaped not only by the technology itself but also by how the content is curated and delivered. In this regard, the study highlights the importance of integrating human-AI collaboration into digital marketing strategies, suggesting that personalized, AI-driven content has the potential to amplify the impact of digital twin technology on consumer behavior and decision-making.

The study also makes significant contributions to the broader field of human-computer interaction (HCI) by examining how AI-driven personalization in digital twin environments can enhance user engagement. Unlike many studies that focus on traditional digital marketing channels, this research positions digital twins as an innovative and immersive interface for consumer interaction, blending virtual and real-world elements to create more engaging, responsive experiences. Through AI-driven real-time personalization, digital twins can offer tailored content that resonates with consumers' individual preferences, driving deeper levels of engagement and increasing the likelihood of conversion. By emphasizing the role of AI in optimizing digital twin interactions, the study contributes to a better understanding of how AI, big data, and immersive technologies can work together to shape the future of digital marketing, offering fresh perspectives on the role of advanced technologies in consumer behavior research. Lastly, this study provides a practical framework for businesses and marketers seeking to integrate digital twin technology into their consumer engagement strategies. The research outlines how companies can leverage digital twins, not merely as visualization tools, but as dynamic platforms for personalized, interactive marketing. By emphasizing the need for real-time responsiveness and personalized advertising, the study offers actionable insights for industries like retail, e-commerce, and entertainment. It also calls for further exploration into AI-driven analytics and immersive content creation, which will be crucial for businesses aiming to stay competitive in an increasingly data-driven, consumer-centric market. Through its comprehensive approach, this study opens new avenues for understanding and applying digital twin technology in the marketing domain, offering both theoretical and practical insights into the future of personalized consumer engagement in digital environments.

This study aims to bridge this gap by exploring the relationship between digital media technology and digital twins, with a particular focus on the moderating role of Human-AI-driven personalized advertising. Through a qualitative research methodology, including semi-structured interviews and case studies of companies utilizing digital twins for marketing and consumer engagement, this research investigates how digital media technology enhances digital twin adoption and how AI-driven personalized advertising influences this process. By integrating the Technology Acceptance Model (TAM) and Media Richness Theory (MRT), this study contributes to theoretical advancements in digital technology adoption and marketing strategies. Additionally, the findings offer practical implications for businesses, technology developers, and marketers seeking to leverage digital twins for AI-driven personalized marketing, ultimately optimizing consumer engagement in an increasingly digital and interactive marketplace.

This paper explores how digital media technology enhances digital twins, with Human-AI-driven personalized advertising as a moderating factor. Using qualitative research, including case studies and interviews, it integrates TAM and MRT to provide theoretical insights and practical implications for AI-driven marketing and digital twin adoption.

2. Literature and Theoretical

The rapid advancement of digital media technology, driven by Human-AI innovation, has revolutionized industries by integrating cutting-edge tools such as augmented reality (AR), virtual reality (VR), interactive media, and real-

time analytics. These technologies have redefined consumer engagement, optimized business operations, and accelerated innovation across various sectors. AR and VR enable immersive experiences that seamlessly merge physical and digital environments, allowing businesses to enhance brand interactions through virtual showrooms, remote collaboration, and digital storytelling. Companies increasingly utilize these technologies to create more engaging and interactive consumer experiences, strengthening brand loyalty and driving market competitiveness.

In addition to immersive experiences, Human-AI-powered interactive media and real-time analytics play a crucial role in enhancing personalized digital interactions. Dynamic content, gamification, and AI-driven adaptive advertising allow businesses to tailor marketing strategies to individual user preferences, increasing engagement and customer retention. Real-time analytics provide deep insights into consumer behavior, enabling data-driven decision-making that refines user experiences and optimizes operational efficiency. However, despite these advancements, the intersection of digital media technology and digital twins remains underexplored. Understanding how AI-enhanced digital media interacts with digital twins can unlock new opportunities for hyper-personalized, immersive marketing strategies. This study aims to bridge this gap by examining the role of personalized advertising as a moderating factor in the relationship between digital media technology and digital twins, offering new insights for both academia and industry.

The evolution of digital twins has shifted from static digital models to dynamic, AI-enhanced interactive systems that replicate physical entities in real-time. These intelligent virtual counterparts continuously update using real-time data, enabling predictive analytics, process optimization, and data-driven decision-making (Tao et al., 2019). Widely adopted in industries such as manufacturing, healthcare, and smart cities, digital twins facilitate advanced simulation, real-time monitoring, and proactive maintenance. In manufacturing, AI-powered digital twins enable engineers to create virtual prototypes, test design scenarios, and optimize production processes, reducing costs and accelerating time-to-market. Similarly, in healthcare, digital twins of organs or entire physiological systems enhance personalized treatment planning by simulating medical interventions and predicting health outcomes. For smart cities, digital twins leverage AI and real-time urban data to optimize traffic flow, improve energy efficiency, and enhance infrastructure management.

Despite their transformative potential, the role of digital twins in consumer engagement remains underexplored. As AI-driven digital twins become more sophisticated, they offer businesses new opportunities to create hyper-personalized, immersive consumer experiences. By integrating digital twins with Human-AI-powered personalized advertising, companies can develop adaptive marketing strategies that respond dynamically to user behavior and preferences. This synergy enables brands to deliver highly interactive, data-driven content that enhances engagement and fosters deeper consumer connections. However, research on how digital twins interact with digital media technology in marketing applications remains limited. This study seeks to bridge this gap by exploring the intersection of digital twins, digital media, and AI-driven personalized advertising, uncovering their collective impact on user engagement and brand perception.

Personalized advertising, driven by Human-AI collaboration and big data analytics, has revolutionized marketing by delivering highly targeted and context-aware content tailored to individual consumer preferences (Lamberton & Stephen, 2016). Unlike traditional segmentation-based advertising, AI-powered personalization dynamically adapts marketing messages in real time, optimizing engagement and conversion rates. E-commerce platforms, for instance, utilize browsing behavior, purchase history, and demographic insights to recommend products uniquely suited to each user, while programmatic advertising ensures precise ad placements at optimal moments to maximize relevance. However, the integration of personalized advertising with digital twin technology remains an emerging area of research. Digital twins, which provide real-time simulations and predictive analytics, could transform customer interactions by delivering hyper-personalized content within digital environments. For example, an AI-enhanced digital twin of a smart home system could analyze user behavior and recommend energy-efficient appliances tailored to household consumption patterns. This study explores how personalized advertising moderates the relationship between digital media technology and digital twins, offering new perspectives on adaptive, real-time marketing strategies.

3. Methodology

This study employs a qualitative research design to explore the interaction between digital media technology, digital twins, and personalized advertising. Given the complexity of these emerging technologies and their dynamic applications, a qualitative approach allows for an in-depth understanding of how businesses and consumers engage with digital twins in marketing and consumer experiences. Specifically, semi-structured interviews are conducted with industry professionals, marketing strategists, and technology developers who have direct experience in implementing digital twin solutions and personalized advertising strategies. This method

provides rich, nuanced insights into the evolving relationship between these technologies, allowing researchers to capture real-world applications, challenges, and future opportunities. The study follows a purposive sampling strategy to identify key stakeholders from sectors such as e-commerce, smart cities, and digital marketing, ensuring that participants have relevant expertise. By focusing on professionals actively engaged in integrating AI-driven personalized advertising with digital twins, this research aims to uncover the mechanisms through which digital media technology enhances consumer engagement and how personalized advertising moderates this interaction. The interviews, conducted via online video calls or in-person meetings, follow an open-ended format, enabling participants to share their insights freely while ensuring consistency in thematic exploration. Each interview is recorded and transcribed for accuracy, followed by thematic analysis to identify common patterns and emerging trends.

To ensure the validity and reliability of findings, this study adopts a triangulation strategy, integrating data from interviews with secondary sources such as industry reports, case studies, and academic literature on digital twins and personalized advertising. Thematic coding is conducted using NVivo software, facilitating the systematic identification of key themes and relationships between digital media technology, digital twins, and consumer engagement. The analytical process follows an iterative approach, refining themes as new insights emerge from the data. Moreover, respondent validation is incorporated by sharing preliminary findings with interview participants, ensuring that interpretations align with industry realities. The study also considers ethical guidelines, guaranteeing participant confidentiality and obtaining informed consent before interviews. By employing a qualitative methodology, this research contributes to the theoretical understanding of digital twin adoption in marketing while offering practical insights for businesses looking to leverage AI-driven personalized advertising. The findings aim to bridge the existing gap in digital twin research by highlighting its consumer engagement potential, ultimately guiding future technological advancements and strategic implementations in digital marketing and smart commerce ecosystems.

4. Results and Discussion

The results of this study reveal several key insights into the interaction between digital media technology, digital twins, and personalized advertising. From the semi-structured interviews, it was evident that digital twins are increasingly seen as valuable tools for enhancing customer engagement, particularly in sectors like e-commerce, healthcare, and smart cities. Interviewees highlighted the ability of digital twins to simulate real-time environments, providing businesses with the capability to test different scenarios and offer tailored consumer experiences. One interviewee from a leading e-commerce platform emphasized that "digital twins allow us to create virtual replicas of user behaviors, which we can use to predict preferences and offer personalized product recommendations." This sentiment was echoed by other professionals, particularly in smart city applications, where digital twins help optimize urban infrastructure by simulating traffic flows and energy usage patterns, thus allowing for personalized services in real time. Personalized advertising was found to be a pivotal moderating factor in this context, enhancing the interaction between digital twins and consumer engagement. Respondents reported that AI-driven personalized advertising, when integrated with digital twin systems, improves user experience by delivering contextually relevant content based on individual behaviors. For instance, one healthcare expert shared, "By using real-time data from digital twins, we can offer personalized health advice through targeted advertisements, which is more engaging for users than traditional methods." These findings suggest that personalized advertising does not just complement but actively strengthens the consumer engagement potential of digital twins.

In analyzing the interviews, three major themes emerged regarding the impact of digital twins and personalized advertising on consumer engagement. First, the ability of digital twins to provide real-time data and predictive analytics was cited as a major factor driving business adoption of this technology. A participant from the manufacturing industry noted that digital twins “allow for predictive maintenance and the testing of new product designs, which leads to more efficient production processes.” Second, AI-powered personalized advertising was consistently mentioned as a powerful tool for enhancing consumer interactions within digital twin environments. The use of personalized content, based on individual preferences and behaviors, fosters greater brand loyalty and improves conversion rates. As one participant from a digital marketing firm explained, "Personalized ads embedded within digital twin systems allow for a seamless experience where consumers feel directly connected to the product or service." Lastly, participants emphasized the challenges in implementing these technologies, including issues related to data privacy, integration complexities, and the need for continuous updates to digital twin models. Despite these challenges, the consensus was that the synergy between digital twins and personalized advertising holds significant potential for transforming consumer engagement strategies. Table 1 below

summarizes key insights from the interviews regarding the integration of digital twins and personalized advertising, highlighting the perceived benefits and challenges.

Table 1. The summarizes key insights from the interviews regarding the integration of digital twins and personalized advertising.

Theme	*Insight*	*Example from Interview*
Real-Time Data & Analytics	Digital twins enhance customer engagement by simulating real-time environments.	"Digital twins let us simulate product usage, allowing for real-time customization of offers."
AI-Driven Personalization	Personalized advertising, when integrated with digital twins, creates more targeted consumer interactions.	"Through AI, we tailor ads based on real-time behaviors, making the experience much more relevant."
Implementation Challenges	Integrating digital twins with personalized advertising poses technical and data privacy issues.	"Data integration and privacy concerns remain a challenge, but the benefits far outweigh them."

The findings from the interviews with industry experts provided valuable insights into the integration of digital twins and personalized advertising, highlighting several key themes that underscore the potential of these technologies in enhancing consumer engagement and optimizing marketing strategies. First, digital twins were widely acknowledged as powerful tools for creating real-time simulations of physical entities, providing businesses with detailed, dynamic representations of consumer behavior, products, and systems. A common finding among the interviewees was the ability of digital twins to enhance personalization. One participant, an expert from the e-commerce sector, shared, “By leveraging digital twins, we are able to simulate individual customer journeys and behavior patterns, allowing us to personalize product offerings in a way that was previously impossible." This ability to simulate and predict consumer actions in real-time offers businesses a significant advantage in refining customer interactions and optimizing their marketing efforts. Several respondents also noted that the use of digital twins allows businesses to identify trends, anticipate consumer needs, and adjust their offerings quickly, which is essential in today’s fast-paced digital environment. Another key finding was the role of personalized advertising in enhancing the effectiveness of digital twins. Interviewees consistently emphasized that when digital twins are integrated with personalized advertising, the resulting user experiences become more relevant and engaging. Personalized advertising, powered by artificial intelligence (AI) and big data analytics, enables brands to tailor their messaging based on individual preferences and real-time behaviors. One marketing professional noted, “Personalized advertising within a digital twin environment provides a real-time, adaptive marketing strategy that changes with every interaction. It’s like having a conversation with the customer that continuously evolves.” This dynamic approach not only improves user engagement but also increases the likelihood of conversion and brand loyalty. The integration of personalized advertisements within digital twins also allows businesses to deliver timely, context-specific content that resonates more deeply with consumers.

Moreover, the interviews revealed that the combination of digital twins and personalized advertising creates a more immersive and interactive experience for users. This is particularly relevant in industries such as healthcare, where digital twins of patients can be used to deliver personalized health advice, or in smart cities, where digital twins can offer customized recommendations for energy consumption or transportation options based on real-time data. A healthcare professional explained, “Incorporating digital twins with personalized advertising has the potential to revolutionize patient care by offering tailored treatments, wellness tips, and health product suggestions based on the patient’s unique data profile." This ability to offer highly personalized content that is both relevant and timely is seen as a significant opportunity for companies to engage their customers in a more meaningful way. However, the interviews also highlighted some challenges associated with these technologies. Many experts mentioned the complexities involved in integrating digital twins and personalized advertising, particularly regarding data privacy and security. One participant pointed out, “While digital twins and personalized advertising offer great promise, businesses must be transparent about data usage and ensure that consumer privacy is respected. This remains a major barrier to full adoption.” Another challenge raised was the need for continuous data updates to maintain the accuracy and relevance of the digital twin simulations. Without frequent data refreshes, the effectiveness of personalized advertisements and the overall value of the digital twin could diminish.

In summary, the interviews revealed that the integration of digital twins with personalized advertising has the potential to significantly enhance consumer engagement and improve marketing strategies. The ability to deliver highly personalized, real-time content within immersive, simulated environments was seen as a major advantage for businesses across various sectors. However, issues related to data privacy, integration complexity, and data maintenance were also identified as areas requiring attention for the successful implementation of these technologies. Despite these challenges, experts agree that the future of digital twins and personalized advertising is promising, with the potential to revolutionize how businesses interact with their consumers.

5. Implication and Conclusion

Our study makes a significant contribution to the growing body of literature on digital twin technology, digital media, and personalized marketing by integrating the Technology Acceptance Model (TAM) and Media Richness Theory (MRT). Traditionally, research on digital twins has concentrated on their applications in industries like manufacturing, healthcare, and smart cities. This study broadens that focus by examining the role of digital twins in consumer engagement and digital marketing. The findings emphasize that digital media technology, when integrated with digital twin systems, significantly enhances their adoption by providing interactive, real-time experiences that improve user engagement and data visualization. This aligns with MRT's assertion that richer media improve communication efficiency and user involvement. The study illustrates that digital twin environments, when paired with advanced digital media tools, can transform how consumers engage with products and services, thereby offering new dimensions for marketing strategies. By combining these two theoretical frameworks, the study sheds light on how digital twins can create more personalized, interactive, and meaningful experiences for users, advancing both theoretical and practical understanding in the digital marketing landscape.

In addition, our research builds upon TAM by introducing personalized advertising as a moderating factor. TAM has long posited that technology adoption is driven primarily by perceived ease of use and usefulness. However, this study extends that framework by showing how personalized advertising can significantly shape consumer perceptions and enhance the perceived relevance of digital twin experiences. The research reveals that consumers are more likely to adopt and engage with digital twin technology when the advertising content is personalized to their individual preferences. This finding suggests that the success of digital twin technology is not solely determined by its technological features but also by how effectively the content is tailored to users. Therefore, the study pushes the discourse on technology adoption forward, emphasizing the interaction between user perception, content personalization, and the technology itself. This integration of personalized advertising within digital twin environments is a critical extension of TAM, illustrating the crucial role of personalized content in the digital marketing domain.

Furthermore, our research contributes to the broader field of human-computer interaction by showcasing how AI-driven personalization can enhance digital twin engagement. While much of the existing research has focused on AI-driven advertising within traditional e-commerce platforms, this study positions digital twins as an evolving marketing platform that offers immersive and interactive experiences blending virtual and real-world elements. The findings indicate that real-time, AI-powered personalization not only enriches consumer experiences but also drives engagement by offering tailored, dynamic content based on user behavior. This research suggests that AI and big data have the potential to reshape digital marketing strategies by leveraging the immersive capabilities of digital twins to create experiences that are both interactive and personalized. By positioning digital twins as the next frontier in marketing interfaces, this study opens new avenues for exploring how AI-driven personalization, combined with immersive technologies, can create more engaging and effective consumer touchpoints in future digital marketing campaigns.

From a practical standpoint, our study offers valuable insights for businesses, marketers, and technology developers seeking to harness digital twin technology in their marketing strategies. One of the central takeaways is that companies should move beyond using digital twins for simple visualization purposes and focus on creating interactive, AI-driven experiences that respond in real-time to user preferences. Such personalized experiences are crucial in industries such as retail, e-commerce, and entertainment, where consumer engagement is key to driving higher conversion rates and customer satisfaction. For instance, a fashion retailer could utilize a digital twin store to analyze how consumers interact with personalized product recommendations, adjusting advertising strategies and inventory in real-time. In the automotive industry, virtual showrooms could use digital twins to offer tailored experiences, providing a higher level of engagement than traditional online catalogs. The findings also highlight the importance of investing in AI-driven analytics, customer behavior tracking, and immersive content creation to unlock the full potential of digital twin-based marketing. In a data-driven marketing age, hyper-personalization is becoming a competitive necessity, and businesses must prioritize these technologies to stay ahead in the market.

This study provides a roadmap for leveraging digital twin technology in innovative ways, offering both academic and practical insights into its role in modern marketing strategies.

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