

Human Digital Twins and the Reconfiguration of Social Interaction

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Abstract: Human Digital Twins (HDTs) are a new concept that has become part of the wider picture of Industry 5.0 and Society 5.0, and aim to simulate a representation of a human being that is dynamic and encompasses not only physiological aspects but also cognitive, emotional, and social characteristics. Although much work has been done on technical architectures and biomedical applications, social aspects of HDTs have received relatively little attention. This paper fills this void by systematically reviewing literature from information systems, sociology, ethics and human-computer interaction to analyze the social dimensions of HDTs. It claims that the HDTs are not just technical products, but are social actors that could interact with and change the main dimensions of human relationship: identity, presence, trust, intimacy, and authority. The paper examines application areas in education, healthcare, employment, interpersonal relations, social pairing and the new industry of the digital-afterlife, to pinpoint opportunities for strengthening social connectiveness and threats of social displacement, identity fragmentation and ethical erosion. It suggests a conceptual approach to the understanding of HDTs as socially grounded, structural-functionalist, post humanist and post phenomenological forms and provides recommendations for human-centred development that maintains a sociality of human beings rather than its loss.

Keywords: human digital twins; social; reconfiguration; virtual attachment; digital; intimacy; human

1. Introduction

Digital twin was first introduced to manufacturing as a virtual copy of physical assets that allows for predictive maintenance and process optimization in Industry 4.0. The change from the modeling machines to the modeling humans, however, represents a substantial qualitative change. Human Digital Twins are often described as a digital person, or a part of a person, represented as a digital entity that is subject of an ongoing bidirectional data thread for synchronization with the human and for providing feedback from the data aggregation and prediction (Gaffinet et al. 2025). Although it is a precise definition, it is extremely misleading in its radical social implications, as it creates digital entities that strive to be human, to define or even replace them in the context of a social interaction. The birth of HDTs is happening in the background of the broader society visualization of Society 5.0, which is presented from a human-oriented society and a convergence of cyberspace and physical space to solve social issues by the Japanese government. In this vision, HDTs play a key role within cyber-physical systems that involve human factors or are designed to engage humans in a personalized way (Fontes et al. 2024). However, the idea of this vision brings up some questions. Is it possible to capture the “social nature” of a human being in a digital representation? How does the interpersonal relationship change if the one component of it is an algorithm, or is an algorithm part of it? Does the emphasis on technol-humanity pull society away from being truly human, as (Fontes et al. 2024) ask directly in their review of the disruptive nature of technol-humanity as Society 5.0? This paper aims to answer these questions by investigating in detail the social aspects of Human Digital Twins. It starts by clarifying the conceptual terrain, separating HDTs from other concepts in the vicinity like avatars, digital shadows and cognitive digital twins. It then explores the social roles that may be assumed by HDTs in several areas, outlining the opportunities and challenges, before moving to a series of illustrative case studies based on recent empirical and ethnographic publications. The paper, based on theoretical approaches from sociology, philosophy of technology and ethics, examines how HDTs re-work the basic social dimensions, and suggests concepts for seeking socially responsible development of HDTs and future research.

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2. Conceptual Foundations: What Are Human Digital Twins?

2.1 Disambiguating the Concept

Recognized as Human Digital Twin, it has several interpretations depending on the application area, leading to confusion in the literature. In the most extensive systematic review of the concept to date, (Gaffinet et al. 2025) examined HDT scholarship in all key application domains and determined that there is an agreement that an HDT's twinned entity is a human individual, with little consensus on what data flows there are between an individual and their digital entity. To overcome this, they suggest a tripartite classification depending on the degree of data integration: Human Digital Models, which do not have an automatic or bi-directional data connection; Human Digital Shadows, which have a unidirectional data flow from man to model; and Human Digital Twins proper, which involve a bidirectional data flow between man and model, allowing the influence of man and model. To overcome this, the authors suggest a tripartite classification depending on the degree of data integration: Human Digital Models, in which there exists no automatic or bidirectional data connection; Human Digital Shadows, in which a unidirectional data flow from man to model exists; and Human Digital Twins proper, in which a bi-directional data flow from man to model and from model to man exists. Another key edge case (Gaffinet et al. 2025) single out is the augmented Human Digital Twin, or a HDT: a person whose body is twinned with a well-integrated technical system, like an exoskeleton or a prosthesis, rather than the human body itself. For social analysis, this difference is significant because it determines whether or not one can engage in truly interactive social dynamics: only HDTs with the ability to influence both ways can do so. A Human Digital Model that only stores biometric information cannot respond socially; a Human Digital Shadow that only observes cannot respond. It is specifically the bidirectional HDT (one that can predict, recommend, or synthesize behavior that feeds back to the twinned human or third parties) that leads to the sociological questions this paper is investigating.

2.2 HDTs versus Avatars: Agency and Autonomy

There is another similar difference between HDTs and avatars. In most cases, avatars refer to a digital entity controlled by the user within an interface environment, while HDTs suggest a more independent relationship between the user and data, and decision-making. From a sociological perspective, the distinction is important; avatars can be thought of as instruments of human agents, while HDTs can be seen as semi-autonomous social actors whose conduct is influenced by algorithmic processes, which are only partially supervised by humans. This neat division, however, is complicated by an ethnographic study by (Lange 2026). Lange is finding that the practical, socio-technical tasks users perform with the designed features of the hardware and software avatars are quite different from the biomedical concept of HDTs as aggregates of physiological data. Digital human distribution, as Lange terms it, is not a single coherent digital twin that replaces a person, but rather a self that is distributed across analog and digital contexts, in fragments and with local, situated meaning, at once. This is an important empirical refutation of the more technologically deterministic descriptions of HDTs that are present in the engineering literature, as discussed further in Section 4.3.

2.3 The Social Body versus the Biological Body

One of the key dilemmas in the discourse of HDT is which part of human beings is considered worth of being digitally reproduced? Biomedical approaches model the human body as a biological system and monitor its physiological functions via wearable sensors. This approach, however, fails to capture one of the core aspects of human nature as social beings – the body as a cultural object: the source of communication and interaction. Erving Goffman's dramaturgical theory is grounded in the idea that human social life is dependent upon embodied performance (the way one presents oneself with one's body, through gesture, expression, and spatial comportment) that cannot be captured in biometric information. Consequently, this tension has real-world consequences, as (Kabalska and Ralf 2024) powerfully describe the social risks of the HDTs. If all that matters is healthcare monitoring, then HDTs might be sufficient but if social interaction is considered, then there are subtle nuances in non-verbal cues, resonance and adaptation that they simply can't handle. On the other hand, if an HDT wants to depict social behavior, it has to deal with the tremendous complexity of human social cognition, the ability to read and react to other people in a manner that is still not fully understood and is hard to replicate algorithmically.

3. Social Functions and Applications

3.1 Education: The Scalable Educator

The education sector is perhaps the most obvious example of the social promise and threat of the HDTs. Teachers are increasingly becoming overwhelmed with workload and are unable to deliver individual interventions, therefore there is an interest in educational twins which allow for personalized support with the retention of social elements. (Sayffaerth 2025) imagines AIEducator duplications that are not only pedagogically effective for imparting knowledge, but also embody trust, empathy, and social presence, which have been shown to be important factors in learning outcomes in practice. The concept is enticing: every student could have a digital version of his teacher to whom he can go for tutoring at any time. But this vision brings up deep social issues. How does the teacher-student relationship change when students communicate with a teacher's digital twin, rather than with the teacher? (Sayffaerth 2025) indicates that the social connection that happens between an AI educator and student does not occur with the original human educator, which creates a number of uncertainties about the possible future changes in how teachers have social interactions with their students. Further, as the digital twin learns its own interactions, if it conflicts with the educator's pedagogical approach, the question arises, what are the student really being taught?

3.2 Healthcare: Personalized Care or Dehumanized Monitoring?

The healthcare sector is the most mature application area of HDTs, which include virtual patients in medical education, as well as personalized treatment planning. Healthcare 5.0 aims to foster new methodologies in healthcare, such as prediction, prevention, personalization and participation, and HDTs are designed to facilitate decentralization of health data and personalized health advice (Fontes, Carpentras and Mahajan 2024). But the social aspects of health services, like trust, empathy, the therapeutic relationship, are not so easily digitized. In particular, (Fontes et al 2024) highlight the use of HDTs in elder care, where it is possible that there

is forced adoption rather than clear, informed consent, driven by the cost and efficiency of adopting the new, rather than the patient's deliberate, informed choice. In the absence of real caring, the humanistic language of Healthcare 5.0 can be the cover for a dehumanizing reality.

3.3 Employment: Performance Enhancement or Surveillance?

In the field of work and organizational psychology, HDTs are marketed as ways to improve employee training, track employee progress, and optimize employee ergonomics. A similar taxonomy of applications that can be achieved with HDTs in Agriculture 5.0 is already present in a parallel literature: from monitoring worker well-being to ensuring safety, optimizing processes, adapting systems, to sharing knowledge, all following the same human-centric approach that is the main driver of Industry 5.0 in general. Both objectives are linked to the pillars of Industry 5.0, human-centricity, sustainability and resilience. But in the labour market, there are strong social issues. Monitoring worker fatigue, and then redistributing tasks, can enhance safety, but also add a new layer of management to what has been primarily a space of bodily experience. If performance reviews are based on comparing human workers to their digital twins, one has to wonder – who or what is being assessed? The danger, both in different ways, is that the HDTs can be used as tools of control, instead of empowerment, to make workers more efficient in the system; instead of working for human flourishing.

3.4 Relationships: Bridging Distance or Manufacturing Intimacy?

One of the most interesting social developments to be encountered by HDTs is the relationship between individuals. The long-distance relationship impacts millions of people, who use technology to keep their emotional and experiential bond with their partner close despite distance. As they noted, the current literature on the digital twin for LDRs consists mainly of works on how to enable the remote connectivity across the three interaction paradigms: system-to-system interaction (e.g., performing intelligent automated tasks), human-to-system interaction (e.g., notifications on one's smartphone, or video calls), and more recently attempts at achieving deeper embodied presence through the use of telepresence robots and shared sensory augmentation. These authors conclude that the majority of the distance-relationship technologies currently available (including smartphone applications, video calls, and wearable technologies) offer only very basic connectivity, and that many of the systems that are called "digital twins" are closer to digital shadows or augmented virtual models in actuality, because they are lacking in any real bidirectional influence. They develop the concept of a post phenomenological perspective on human-technology-world relations in the spirit of Don Ihde, and consider how prospective technologies for human-human, human-technology, and human-human-technology relationships might transform interaction from an embodiment relationship (the technology is an extension of the self) to a hermeneutic or alterity relationship (the technology is an interpretable, quasiother presence) and the implications of this shift for the experience of authenticity in a mediated relationship of the human technology world kind (HTW) (Li et al. 2025). The issue around authenticity gets more pronounced, however, when digital twins are used not just to maintain the current relationships, but to create new ones. (Ye et al. 2025) introduce CogniPair, a multi-agent system that realizes the Global Workspace Theory to create a psychologically realistic digital twin of human subjects that is realized by personality profiles derived from their observed behaviors rather than self-reported types, and simulates dating interactions and job interviews before they happen. The system was tested on the Columbia University Speed Dating dataset with 551 digital-twin agents, which simulated over five thousand dates, and found to have a 72 percent correlation with human attraction patterns, 77.8 percent accuracy in predicting matches, and 74 percent agreement with human validators (Ye et al. 2025). Such platforms boast the capability to evaluate two-way cultural match for romantic relationships as well as for job-fitting. Such applications can increase matching efficiency and decrease the number of wasted encounters, but they also add yet another layer of algorithmic mediation to some of the most personal human decisions – who will love, who will hire – and raise the question of whether or not efficiencies of this type come at a price of reducing the unpredictability and risk that is so central to human connection.

3.5 The Digital Afterlife: HDTs Beyond the Twinned Human's Life

Another application, which has been further explored, is to use the HDT concept outside of the boundaries of the twinned individual's own life. So-called griefbots and deadbots, conversational agents trained from messages, recordings and social media history of a deceased person, and simulating continued interaction with the living, are a limit case of the HDT concept, where the bidirectional data thread that defines a true HDT has been cut on one side. Critics studying this new digital-afterlife sector note different moral issues concerning consent (the deceased does not have the opportunity to agree to the use of their image or likeness), grieving (the continued interaction in a simulacrum environment may prove problematic rather than helpful for grieving), and commercial exploitation (postmortem data as a saleable asset). This limit case is a teaching moment because it highlights, in particularly dramatic fashion, issues of authenticity, consent and ownership that arise in all the cases of HDT considered in this paper, which are explored in more detail in Sections 5.2 and 5.3.

4. Theoretical Frameworks for Social Analysis

4.1 Structural Functionalism: HDTs as Social Institutions

The social role of the HDTs can be examined using the structural functionalism lens. This way of thinking sees society as a system of interdependent components that each perform functions that ensure the stability and cohesion of the system. In this perspective, the HDTs are the new institutions which need to adapt the existing social institutions and individuals. The integration process is not value neutral. As outlined in Section 3, social functions can be displaced by HDTs, for instance, by depriving people of opportunities for human mentoring in education or human care in the health sector. The key point of the structural functionalism is the need to have social balance, where technological integration helps to reinforce the social balance instead of destroying it. If the HDTs carry out social functions that previously have been done by humans, it is not only a question of whether they can do them well, but whether they keep the social fabric the functions were a part of.

4.2 Dramaturgical Sociology: The Presentation of Digital Self

A second important consideration is Erving Goffman's dramaturgical approach. Goffman saw social life as being performed by the people involved, and the impression management of the body to insure desired social identities. With the introduction of HDTs, this performance is drastically changed: The presentation of self can take place in both digital and analog environments, which leads to questions about authenticity, consistency, and audience perception in both environments.

HDTs also involve a complex relationship between performer and performance. But, if the digital twin is semi-autonomous, then who is operating it is truly up for debate. During interactions with others, whose impression management is at play—twin humans or the emergent behavior of the system? The dramaturgical perspective proposes that the interactions of HDT change the nature of the back-stage and front-stage dynamics, and consequently the nature of the relationships in which trust and authenticity are operative, in the very domains studied above – education, healthcare, relationships.

4.3 Posthumanist Critique: Toward Digital Distribution

A more radical theory view argues the notion of twinning itself. Based on her ethnographic understandings of the practices of avatars in schools discussed in Section 2.2, (Lange 2026) suggests that the products rather than being a twin are a digital distribution: the human self is not a copy, but is distributed across analog and digital contexts, and that this means that the language of 'twinning' conceals the implications of coherence and agency. This echoes a more mature critique of the post humanist project emerged from the work of (Hayles 1999), who suggested that the division between the embodied human and the informational human is more permeable than the information list literature on twins and copies suggests and more constructed. This view attempts to refute the presumed duality of the HDT discourse, the idea of an original and a copy in the digital space. Rather, it posits that human identity is always and everywhere multiple and performative, and that HDTs are one additional context in which identity is created. Rather, then asking whether the HDTs are true to humans, the question can be shifted to how they continue to constitute the human being, with profound implications for risk understandings as outlined in Section 5.

4.4 Post Phenomenology: Human-Technology-World Relations

This fourth framework, which is based on a philosophy of technology, is particularly helpful for the applications of relationships discussed in Section 3.4. In the post phenomenological account of Don Ihde, technology mediates a person's relationship to the world in several different ways: as an embodiment relation (when a technology is so seamlessly absorbed by the individual that it appears as an extension of his or her perception and actions); as a hermeneutic relation (when the technology has to be interpreted like a text before the world it reveals becomes meaningful); and as an alterity relation (when the technology is encountered as the quasi-independent other it is). When applied to the notion of potential long-distance relationships with an HDT, the relationship a user has to the HDT changes from an embodiment relation (a tool to connect to a distant partner) to a hermeneutic or even alterity relation where the HDT itself becomes a subject to be interpreted and related to separately from the user. In the context of potential long-distance relationships with an HDT, (Li et al. 2025) demonstrate that the relation between the user and the HDT passes from an embodiment relation (a tool to reach a distant partner) to a hermeneutic or even alterity relation, where the HDT itself becomes a relation to be interpreted and related to independently of the user. This is important because it alters what it is that is being told at the other end of an HDT-mediated relationship is it still, clearly, the human partner, or is it more and more the system itself?

5. Ethical Dimensions and Social Risks

5.1 Identity, Authenticity, and the Problem of "Barbie World"

A theme that is often discussed in the context of HDT is the danger of developing idealized digital renditions, which do not resemble the original humans. (Kabalska and Ralf 2024) caution that the filter of negativity and constant self-optimization can lead to an HDT that can develop into a Barbie World of manufactured perfection. People may have a diminished self-esteem and self-perception when comparing themselves with their ideal digital twin. This is especially the case when HDTs are designed to be more efficient than humans. Learning twins may be more patient, more consistent and knowledgeable than any actual teacher. An algorithmically matched agent, as suggested in (Ye et al. 2025) that algorithmically matched agents can beat chance in predicting attraction, may be more attention-giving and less demanding than a relationship partner. Optimizing, or simply being "outcompeted" without being noticed by, one's own HDT creates significant questions surrounding what it means to be human in the age of digital perfection, as (Kabalska and Ralf 2024) explicitly pose in their larger critique of the general HDT-acceptance hypothesis.

5.2 Privacy, Autonomy, and Consent

In order for HDTs to operate effectively, they necessitate a significant amount of personal data, posing significant privacy concerns. Nevertheless, the social aspects of privacy extend beyond the narrowly defined concept of data protection. HDTs create new possibilities for social control, manipulation, and surveillance by gathering and processing personal information. Because a true HDT is bidirectional, data flows from digital representation back to the human, potentially influencing behavior in ways that compromise autonomy, in addition to being from human to digital representation (Gaffinet et al. 2025) Particular consent concerns are raised by the institutional deployment of HDTs in 2025. Implementation without fully informed consent may be driven by cost and efficiency pressures, particularly in situations like elder care where individuals may have limited practical options (Fontes et al. 2024). Section 3.5's discussion of digital-afterlife applications demonstrates the logical extremeness of this issue: a deceased individual is unable to make a retroactive or otherwise consent to the specific methods of subsequently utilizing their digital likeness. A reality of algorithmic control exercised by whichever party actually holds the data may be concealed by the rhetoric of personalization, which is present in all these contexts.

5.3 Ownership and the Question of Who Controls the Twin

An ongoing and still unsettled discussion revolves around HDT ownership in the literature. (Fontes et al. 2024) highlight a real divide among researchers on this issue: some believe that individuals linked to HDTs are the rightful owners by nature, while others argue that this ownership does not automatically include control over the data or its sharing with others. Another viewpoint suggests that HDTs can serve as an empowering tool, offering individuals a practical way to oversee and potentially profit from

their personal data according to their preferences. The unresolved nature of this argument has practical implications, determining who can control an HDT's actions, who benefits from its data, and who is accountable if the HDT's activities lead to social or reputational harm to the individual it represents.

5.4 Bias, Inequality, and Social Justice

AI systems, including HDTs, have a tendency to magnify existing biases. If an HDT mirrors the viewpoints or unconscious prejudices of its human creator or is influenced to do so, it could exacerbate inequalities and have adverse effects on specific groups on a large scale. This issue has been highlighted in the educational-twin literature (Sayffaerth 2025). Additionally, the substantial expenses associated with developing and implementing HDTs could contribute to the emergence of new digital disparities, as discussed extensively in this literature. This situation could benefit individuals who can afford personalized digital aides while marginalizing others.

The implications for social justice also apply to job markets. HDTs that excel human workers in specific, quantifiable criteria might lessen the perceived need for human involvement, diminishing the value of human positions and potentially displacing employees (Fontes et al. 2024). The vision of human-machine collaboration championed in the Industry 5.0 literature could, in reality, be used as a retrospective justification for substituting humans instead of genuinely enhancing their capabilities.

5.5 Social Displacement and the Erosion of Human Connection

The primary social risk associated with HDTs is the decline of genuine human connections. When HDTs are used as substitutes for human interaction in areas like education, healthcare, and relationships, the chances for real human contact decrease. It is not just that HDTs are inadequate replacements - as indicated in the theoretical frameworks in Section 4, they are likely to be insufficient in different ways in each field. The concern is that replacing human interaction with HDTs might alter human expectations and abilities for connection gradually over time. (Sayffaerth 2025) cautions that interactions with AI educators could not only change how students engage with teachers but also impact their interactions with people in general, potentially affecting empathy, trust, and views of authority in the long run. The central worry, as highlighted in the education, healthcare, and relationship studies discussed in Section 3, is that HDTs might teach humans to interact with others in manners that are guided by algorithms and consequently lacking in richness, limiting rather than enhancing the human potential for authentic interpersonal relationships.

6. Illustrative Case Studies

6.1 CogniPair: Psychological Authenticity as a Design Goal

The CogniPair system, created by Ye and colleagues in 2025, is currently the most extensively researched effort to construct an HDT with genuine psychological depth, not just simulated. Instead of using manually created characters, the system deduces the Five-Factor personality profile of each digital twin from the individual's behavioral choices in a specially designed adventure-style evaluation. This method aims to bypass the bias in self-presentation that affects traditional personality tests. Each digital twin is then represented as a group of specialized cognitive sub-agents, managing emotions, memory, social conventions, planning, and goal monitoring. These sub-agents are coordinated using a computational version of Global Workspace Theory's broadcast mechanism, rather than as a singular language-model persona. The system's ability to forecast actual human attraction patterns and compatibility outcomes demonstrates that the bidirectional, dynamically-evolving HDT described in Gaffinet and team's 2025 definition is technically feasible, particularly in the limited and well-monitored setting of speed dating. However, this success raises questions about authenticity and control highlighted in Sections 3.4, 5.1, and 5.3: a digital twin that can predict a person's compatibility better than the person themselves poses a potent tool but also introduces a new form of authority over intimate information about that individual.

6.2 Avatars in Schools: An Ethnographic Counter-Case

(Lange 2026) research on how schoolchildren utilize avatars presents a contrasting perspective to the prevailing engineered view of HDTs in the literature. In contrast to the common approach in biomedical HDT studies where users merely adopt the standard physiological-data-aggregate model, the students in Lange's study actively repurposed the visual elements of avatars to navigate social interactions among peers in innovative and unexpected manners. For example, they utilized avatars as a means to maintain friendships in a socio-technical context rather than as accurate reflections of themselves. This discovery holds significance for the current paper's argument in two main ways: firstly, it provides concrete empirical evidence to support the criticism of digital distribution as discussed in Section 4.3, and secondly, it serves as a reminder that the actual social role of an HDT is greatly influenced by how real users, especially young users, choose to interact with it in real-world scenarios, regardless of its intended design and specifications.

6.3 HDTs as Crisis-Prevention Tools: A Speculative Extension

(Kabalska and Ralf 2025) latest research builds upon their previous criticism of HDTs by exploring a more speculative approach. They suggest that the human digital twin could serve as a tool for preventing crises in high-stakes negotiations, drawing on recent instances of failed interpersonal diplomatic communication. The idea is that an HDT that can simulate a negotiating partner's probable emotional reactions and boundaries might assist human negotiators in avoiding mistakes that could lead to escalation. While this concept has not been proven on a large scale like CogniPair, it exemplifies the dual nature present in all applications discussed in their paper. The same ability to model interactions from both sides, which could avert a diplomatic crisis, is the same capability that gives rise to concerns regarding surveillance, authenticity, and ownership as highlighted in Sections 3.3 and 5.2-5.3.

7. Discussion: Toward Human-Centered HDT Development

7.1 Keeping Humans in the Loop

A common suggestion found in this body of literature emphasizes the significance of involving experts and all relevant stakeholders in the process, ensuring that Human Decision Technologies (HDTs) enhance human judgment instead of replacing it. This

concept should be applied to each stakeholder mentioned in Section 3: educators in educational simulations, healthcare providers in medical HDTs, and individuals themselves in personal HDTs like CogniPair. The aim is to foster collaboration between humans and machines, rather than substituting humans entirely. In practical terms, this implies creating HDTs with clear mechanisms for human supervision and interference. HDTs must be open about their characteristics and limitations, clearly indicating when an interaction involves a digital representation rather than the actual human represented. Users should maintain ultimate control over HDT decisions that significantly impact them, in line with the ownership discussion outlined in Section 5.3.

7.2 Designing for Authentic Sociality

If Humanoid Digital Technologies (HDTs) are meant to enhance social interaction rather than just imitate it, they need to be crafted to maintain genuine social connections. This involves considering the non-verbal, emotional, and situational aspects of human communication that Goffman's dramaturgical approach emphasizes and that can be overlooked in digital formats. It also involves recognizing the limitations of HDTs: as indicated by various sources, complex and truly social interactions may need to remain predominantly within the realm of human interaction to retain the advantages of personal involvement. Studies should pinpoint which social components of communication are crucial for favorable results and which can be effectively transferred to a digital setting without compromise. For instance, in the field of education, it is important to determine which aspects of the teacher-student dynamic – such as trust, empathy, authority, and personal rapport – genuinely enhance learning, as opposed to the mere delivery of information that an HDT could adequately replicate. Without concrete evidence on this matter, deploying HDTs runs the risk of optimizing for the wrong factors.

7.3 Ethical Frameworks and Governance

The ethical frameworks and governance mechanisms for handling the social risks associated with HDTs need to be strong. These frameworks should cover issues like data privacy, consent, bias, and accountability, determining who should be held accountable when harm occurs due to an HDT, be it reputational, financial, or emotional. The urgency of this need is highlighted by the widespread adoption of HDTs in various sectors such as education, healthcare, employment, relationships, and the emerging digital-afterlife industry, all of which lack adequate regulatory supervision. To ensure effective governance at the policy level, it is crucial to standardize HDT concepts and practices, as attempted by (Gaffinet et al. 2025) in defining terms. Collaborative efforts spanning different disciplines are necessary to establish shared definitions, quality benchmarks, and ethical principles. Initiatives like the European Union's Virtual Human Twins Initiative are significant steps in this direction, yet addressing issues of ownership and consent, as discussed in Section 5, requires more than just technical standardization. Research on the social implications of HDTs lags behind technical research, indicating a need for further exploration. Key research priorities include:

1. Conducting empirical studies on how individuals interact with HDTs and how they respond to these interactions beyond the controlled settings seen in existing research.
2. Long-term studies to understand the effects of prolonged HDT use on relationships, identity, and social skills over extended periods.
3. Comparative studies to analyze how social dynamics vary across different HDT applications in education, healthcare, employment, and relationships, and whether the risks identified in Section 5 manifest differently in each context.
4. User-focused design research using ethnographic methods to explore how individuals actually use and adapt HDTs to their needs.
5. Ethical and policy research to address ownership issues raised in Section 5.3, including the specific governance requirements of digital-afterlife applications discussed in Section 3.5.

8. Conclusion

Human Digital Twins are a significant technological advancement that has wide-ranging social consequences. They have the potential to improve education, healthcare, employment, and relationships, as evidenced by the findings from systems like CogniPair. However, there are also dangers of causing social displacement, identity fragmentation, and ethical decline as outlined in this document. The concept of Society 5.0, a society focused on humans enhanced by the convergence of cyber and physical elements, hinges on how HDTs are created and utilized to truly benefit human well-being instead of solely optimizing quantifiable indicators of it. The argument made in this paper stresses that the social implications of HDTs should be at the core, not on the periphery, of their advancement. HDTs are more than just technological products; they are social entities that can transform key aspects of human connections. Integrating them into current social frameworks necessitates careful consideration of social interactions, ethical values, and human requirements, drawing from various frameworks like structural-functionalist, dramaturgical, posthumanist, and post phenomenological perspectives discussed in Section 4. Rather than striving for perfect digital replicas, the objective should be to enrich human social bonds, retaining the essence of meaningful human interactions even as they are extended through digital mediums. Moving forward, progress will require collaborative efforts across disciplines involving technologists, social scientists, ethicists, and community stakeholders. It demands a realistic view of technology's capabilities and a watchful eye on its potential to displace existing norms. Above all, it mandates a core belief that technology must benefit humanity, not the other way around a principle that grows more crucial as the line between human and digital realms, as described by (Hayles 1999; Lange 2026), becomes increasingly blurred.

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