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赛博学（Cyberism）——研究人与网络空间的学说

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摘　要　自早期人类以来的大约 700 万年中，人类一直生存在三个基本空间中，即物理空间（自然空间），社会空间和思维空间（认知空间）. 但随着电子计算机的诞生，以及后来的互联网和人工智能技术的发展，人类的生产和生活方式已经发生了极大改变，即在原来的三个基本生存空间之外，诞生了一个新的生存空间，即赛博空间（Cyberspace，网络空间）. 在我们的传统文化中，儒（Confucianism）是研究人与人（社会空间）的关系，释（Buddhism）是研究人与内心（思维空间）的关系，道（Daoism 或 Taoism）是研究人与自然（物理空间）的关系，而人与赛博空间（网络空间）关系还未得到深入研究. 本文首先提出赛博学（Cyberism）是专门研究人与赛博空间（网络空间）关系的学说，系统阐述赛博学中的一些基本问题，如：赛博哲学、赛博科学与赛博逻辑问题；赛博学中若干"人"的问题；赛博学中科技发展、社会与认知，以及网络空间生存带来的疾病与健康问题等. 其次研究了赛博空间引起的学科变革，即赛博学的学科体系及其对传统学科体系的影响. 最后展望了赛博学对未来人类文明进化、教育与科技创新的影响.

关键词　赛博空间；赛博学；人机关系；数字人；网络病；学科体系；科技与文明进化
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Cyberism: The theory for relationships between human and cyberspace

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ABSTRACT　Approximately more than seven million years since early humans, humanity has existed within three fundamental spaces: physical (also known as the natural space), social, and thinking (also referred to as the cognitive space) spaces. The physical space represents the interaction between humans and the natural environment; the social space reflects the network of relationships among individuals; and the thinking space includes human consciousness, cognition, and the spiritual world. However, with the advent of electronic computers and the subsequent development of the internet and artificial intelligence, human status of production and living have undergone significant changes. A new space—cyberspace—has emerged beyond the original three fundamental spaces. This space not only encompasses human activities in the digital environment but also significantly influences identity construction, social behavior, value systems, and ideologies. New digital phenomena such as livestream commerce, the gig economy, metaverse, virtual humans, online education, and digital social interactions are rapidly expanding the dimensions of human life, leading to unprecedented behavioral patterns and social structures. In traditional Chinese culture, Confucianism studies the relationship between people (social space), Buddhism explores the relationship between individuals and their inner minds (thinking space), and Daoism (or Taoism) focuses on the relationship between humans and nature (physical space). However, the relationship between humans and cyberspace has not yet been thoroughly explored. In response to this significant transformation, this paper introduces the concept of Cyberism, a new school of thought developed as a counterpart to Confucianism, Buddhism, and Daoism. Cyberism is dedicated to systematically exploring the

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fundamental relationship between humans and cyberspace and establishing new principles for existence, behavior, and ethics within this digital realm. It views cyberspace not only as a technological extension but also as a full-fledged existential domain that demands its own philosophical, scientific, and normative framework. This study focuses on several fundamental issues in Cyberism. These include problems related to cyber philosophy, cyber science, and cyberlogic. It also examines questions concerning the notion of "the human" in Cyberism, such as cyborgs, digital humans, digital twin humans, and robots. Furthermore, it explores issues of technological development in Cyberism, including sense–communication–computation–storage, the transformation from data to intelligence (data–information–knowledge–intelligence), the progression from artificial narrow intelligence to artificial general and super intelligence (ANI–AGI–ASI), human–machine integrated intelligence, and artificial consciousness. This study also considers social and cognitive challenges, including cyber ethics and morality, culture and art, gender, psychology, and governance. Additionally, it discusses health and disease issues arising from existence in cyberspace. In addition, this paper elaborates on a disciplinary framework for Cyberism encompassing the natural, social, cognitive, and cyber sciences. Based on the cyber–physical–social–thinking (CPST) space, it outlines a new approach to disciplinary organization and highlights the transformation of traditional academic structures. Finally, it explores the challenges and opportunities that Cyberism presents for the evolution of human civilization, education, and technological innovation. Cyberism, as a pioneering field bridging humanities and cyberspace, offers not only a theoretical lens for navigating digital transformation but also a potential philosophical and ethical cornerstone for sustaining human dignity, purpose, and development in an increasingly virtualized world.

KEY WORDS cyberspace; Cyberism; human–machine relationship; digital human; cyber-syndrome; disciplinary system; technological and civilizational evolution

自早期人类诞生以来,大约经过了 700 万年.在这漫长的时间内,人类有三个基本生存空间,即物理空间、社会空间和思维空间.现代电子计算机诞生还不到 100 年,但这短短的几十内,却诞生了互联网、物联网、大数据、人工智能等一系列新事物,并逐渐形成了强大的赛博空间(Cyberspace, 网络空间),是人类的第四个基本生存空间.赛博空间极大地改变了人类的生存与生产方式,也将改写人类文明史和宇宙史[1].

在中国传统文化中,儒(Confucianism)主要研究人与人(社会空间)的关系;释(Buddhism)主要研究人与内心(思维空间)的关系;道(Daoism, 也称为 Taoism)主要研究人与自然(物理空间)的关系.考虑到赛博空间已经深入到人类生产与生活的各个方面,且人与赛博(网络)空间的关系还未得到深入研究,本文提出赛博学(Cyberism, 简称"赛"),以研究人与赛博(网络)空间关系.

本文围绕赛博学,首先阐述赛博学的定义.其次研究赛博学中的一些基本问题,包括:赛博哲学、赛博科学与赛博逻辑问题,赛博学中若干"人"的问题(赛博格、数字人、数字孪生人、机器人),赛博学中科技发展问题(感知–通信–计算–存储、数据–信息–知识–智能、专用智能–通用智能–超级智能(ANI–AGI–ASI)、人机融合智能,以及人工意识),社会与认知问题(如网络空间伦理与道德、文化与艺术、性别、心理和治理等),网络空间生存带来的疾病与健康问题.再次研究了赛博学的学科体系,讨论了传统学科体系的变革.最后展望了赛博学对人类文明进化、教育与科技创新的挑战和机遇.

1 赛博学定义

赛博学(Cyberism),简称"赛",是继儒、释、道之后,研究人与网络空间(Cyberspace, 也称为赛博空间,是人类生存的第四个基本空间)基本关系与生存法则的学说,如图 1 所示.赛博学内容丰富,

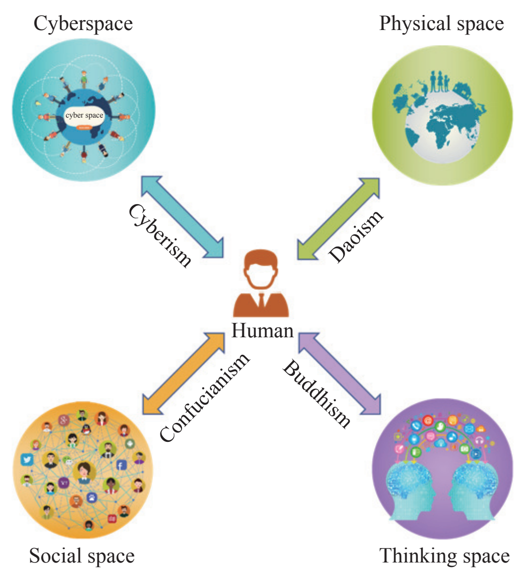

图 1 人与四个基本生存空间的关系:儒、释、道与赛博学

Fig.1 Relationship of humans with the four basic living spaces: Confucianism, Buddhism, Daoism, and Cyberism

既包括哲学、科学等层面，也包括协调治理、伦理道德、文化艺术、认知与心理、疾病与健康等诸多层面. 赛博学将产生一系列新的基本问题，并对传统的人与自然、人与社会、人与认知问题产生挑战，也将系统变革现有学科体系，对人类文明及宇宙探索产生深远影响.

2 赛博学基本问题

2.1 赛博哲学、赛博科学与赛博逻辑问题

2.1.1 赛博哲学

赛博哲学（Cyber philosophy）是研究数字时代技术、存在、认知和伦理问题的新的哲学分支，探讨虚拟与现实、人机关系、数据本体论、人工智能意识等议题. 它结合传统哲学理论与赛博空间（Cyberspace）的独特属性，回应技术对社会、文化和人类本质的重构[2−5]. 赛博哲学有五大核心内容，如表 1 所示.

赛博哲学作为对数字时代技术与人类存在相互作用的系统性思考，既借鉴了传统哲学的本体论（Cyber-ontology）、认识论（Cyber-epistemology）与现象学方法（Cyber-phenomenology），也融合了网络科学、人工智能研究和后人类主义视角. 在本体论层面，它重审了虚拟对象的"实在性"与数字–物理边界[6−7]. 在认识论层面，则揭示了信息流动及算法决策背后的价值建构[8]. 而在现象学维度中，主要关注在数字环境中身体经验的再现和重构，其核心在于将梅洛–庞蒂所提出的身体–主体观延展至虚拟空间，并考察技术如何介入主体的身体–世界关系，重新定义"在世存在"的实践优先性[9].

与此同时，赛博哲学关注数字化权力结构与伦理边界（Cyber-ethics and cyber-politics），将数据隐私与算法治理纳入政治哲学议程，呼吁在后人类语境下重塑主体与权利话语[10]. 赛博美学（Cyber-aesthetics）则聚焦生成式 AI 与沉浸式互动如何挑战传统艺术理念，强调交互性与空间体验在当代数字艺术中的核心地位[11]. 整体而言，赛博哲学为理解技术时代的人机共生与社会变革提供了跨学科而富有前瞻性的理论框架.

2.1.2 赛博科学

赛博科学（Cyber science）是一门新兴的交叉学科，主要关注网络空间及网络使能的物理、社会和思维（Cyber–physical–social–thinking, CPST）空间所产生的现象、问题和应用[5]. 它旨在通过对网络空间相关的事物和现象进行科学研究，构建关于网络空间的知识体系，并为网络空间的发展和应用提供理论支持和技术指导. 其研究范围涵盖了网络空间中的科学与技术问题，网络空间对人类社会、文化、思维等方面的影响和挑战，涉及到计算机科学、信息科学、社会学、哲学等多个学科领域的知识和技术. 赛博科学的主要内容如表 2 所示.

赛博科学涵盖众多的交叉学科，首先聚焦于网络与物理系统的集成与可靠性研究，即"Cyber physical science"范畴. 当前研究常采用分析模型、仿真模型及混合模型来评估与优化网络物理系统的可靠性和稳定性，其中故障树分析与马尔可夫模型是典型的方法框架[12]. 在社会层面，"Cyber

表 1　赛博哲学的主要内容

Table 1　Key elements of cyber philosophy

Areas	Core issues	Core perspectives
Cyber-ontology	Virtual positivity; digital dualism; hybrid ontology; social ontology; virtual digitalism	Virtual objects have causal dynamics and can be treated equally with physical entities; certain scholars advocate two separate orders for the digital and the physical; practices such as augmented reality demonstrate the dissolution of the boundary between the two
Cyber-epistemology	Knowledge generation and validation; network structure; algorithmic bias; semantic coherence; socio-cultural embedding.	Information is encoded and transmitted in distributed systems, and AI (Artificial intelligence) "understanding" must satisfy semantic and coherence criteria; algorithmic bias is both a technological flaw and an entrenchment of values
Cyber-ethics and Cyber-politics	Data privacy; algorithmic power; post-human subjectivity; governance mechanisms	The right to privacy debate focuses on property versus human rights attributes; algorithmic governance becomes a new form of power, requiring transparency and accountability; the expansion of cyborg rights calls for ethical reconfiguration
Cyber-phenomenology	Embodied interaction; virtual body belonging; technological mediation; culture of connectivity	Immersive interaction in VR (Virtual reality) highlights the practical nature of bodily experience; technology not only mediates perception, but shapes social presence and online identity performance
Cyber-aesthetics	Generative AI art; interactivity; immersive aesthetics; media reconfiguration	Digital art is both an algorithmic product and carries cultural intent; immersive and interactive experiences break traditional viewing patterns and reshape the relationship between aesthetic subjects and space

表 2 赛博科学的主要内容

Table 2 Key elements of cyber science

Areas	Core issues	Core perspectives
Cyber physical science	Integration of cyber and physical systems; real-time control and monitoring; resource optimization; system reliability and stability	Study of the interaction between cyber and physical systems to achieve seamless integration and efficient operation
Cyber social science	Social phenomena in cyberspace; social network analysis; social behavior prediction; social influence and opinion leadership.	Exploration of social structures and behaviors in cyberspace to understand and manage social dynamics
Cyber data science	Big data processing and analysis; data mining and knowledge discovery; machine learning and AI; data security and privacy protection	Development of advanced data processing and analysis techniques to extract valuable insights from large-scale datasets
Cyber cognitive science	Human–computer interaction; cognitive models and architectures; cognitive enhancement and augmentation; emotional computing and affective interaction	Investigation of human cognitive processes and the development of technologies to enhance human cognitive abilities and facilitate natural human–computer interactions
Cyber security science	Cyber threats and vulnerabilities; attack detection and prevention; security protocols and encryption; risk assessment and management	Establishment of comprehensive security mechanisms to protect cyberspace from various threats and ensure secure information sharing and system operation
Cyber infrastructure science	Network architectures and protocols; cloud computing and distributed systems; edge computing and IoT (Internet of things); High-performance computing and storage	Design and optimization of robust and scalable cyber infrastructures to support diverse applications and services
Cyber space science	Modeling and representation of cyberspace; geographical information systems; spatial analysis and visualization; cyber geography and cartography	Study of the spatial characteristics and geographical information of cyberspace to enable accurate spatial analysis and visualization
Cyber governance science	Cyber law and regulations; cyber ethics and moral norms; cyber governance models and mechanisms; cyber policy and strategy	Formulation of effective governance frameworks to ensure the orderly development of cyberspace and address legal and ethical issues

social science”视角下的研究表明, 网络空间中的社会网络结构、意见领袖效应与行为预测对于理解虚拟社区的动态至关重要. 例如, 社交赛博安全学(Social cybersecurity)倡导跨学科合作, 利用社会科学理论来设计防御性策略以对抗网络舆论操纵[13]. 数据科学(Cyber data science)在赛博科学中占据核心地位, 其强调从大规模网络数据中挖掘价值, 结合机器学习与人工智能技术, 以提升决策控制、知识发现、威胁检测与隐私保护等能力. 例如, 网络安全数据科学流程(Cyber data science process)已被提出以规范数据在网络行动中的应用[14]. 认知科学方面, “Cyber cognitive science”聚焦于人机交互与认知增强. 研究发现, 情感计算与认知模型能够显著提升用户在安全决策中的性能与体验, 从而在增强网络素养与社交安全中发挥作用[15]. 最后, 在安全科学与治理方面, “Cyber security science”与“Cyber governance science”共同支撑了对威胁识别、风险评估、加密协议与法律伦理框架的全面构建. 例如, 对后量子密码学的迁移框架及政府主导的政策制定正迅速成为研究热点, 以保障未来网络安全韧性[16].

2.1.3 赛博逻辑学

赛博逻辑学(Cyberlogic)融合了传统逻辑学与计算机科学、人工智能和网络安全等领域, 旨在为赛博空间中的复杂推理、协议验证和智能决策提供坚实的理论支撑与实践方法[1,17]. 随着赛博空间的发展, 赛博逻辑学逐渐成为连接赛博哲学和赛博科学的桥梁, 如图 2 所示. 其概念由传统逻辑拓展而来, 强调赛博及赛博使能实体在 CPST 空间中的逻辑关系, 它不仅将传统逻辑学的概念和方法引入赛博空间, 还针对赛博空间的特点和发展需求进行了创新和拓展, 为赛博空间中的复杂问题提供了系统的逻辑分析和解决方案[3].

图 2 赛博逻辑学是赛博哲学到赛博科学的桥梁

Fig.2 Cyberlogic as a bridge from cyber philosophy to cyber science

赛博逻辑学的主要内容如表 3 所示. 在赛博使能物理空间(CeP, Cyber-enabled physical space)中的赛博逻辑, 主要探讨如何通过赛博化手段克服物理空间中物体受时空限制的问题, 其核心在于研究赛博空间中物体之间的交互关系, 以及如何利用空间–时间属性来实现无限制的空间交互、非

表 3　赛博逻辑学的主要内容

Table 3　Key elements of cyberlogic

Areas	Core issues	Core perspectives
Cyber-enabled physical space (CeP) logic	How does CeP logic reflect object relationships and overcome physical space limitations?	Focuses on spatialtemporal attributes, including unrestricted spatial interactions, non-unidirectional temporal interactions, and spacetime interactions. Cyberization enables new object interaction methods, breaking the limitations of distance and unidirectional time in physical space
Cyber-enabled social space (CeS) logic	How does CeS logic reflect individual-to-cyber-entity mapping and change social activity analysis?	Involves homogeneous social existence, social relationships, and social lifestyles. In CeS space, individuals can have multiple social roles, social relationships are less restricted, and social lifestyles are altered, such as modeling social activities to analyze relationship formation probabilities
Cyber-enabled thinking space (CeT) logic	How does CeT logic help understand and analyze human thinking and build machines with thinking abilities?	Covers cyber-based brain research, brain-abstracted cooperation, and self-learning cyber brains. It includes collecting brain data, simulating brain mechanisms, detecting brain signals and behaviors to construct cognitive models, and advancing self-learning cyber brains for machine intelligence

单向的时间交互和时空交互，从而为解决物理空间中的问题提供新的思路和方法. 赛博使能社会空间(CeS, Cyber-enabled social space)中的赛博逻辑则聚焦于人到赛博存在个体的映射，以及如何改变人类社会活动的分析方法. 重点在于理解赛博逻辑如何改变人们在社会空间中的角色扮演、关系建立和生活方式，例如通过分析社会活动来建立模型，分析陌生人之间形成关系的概率等，进而揭示赛博社会空间中人类行为的新规律. 在赛博使能思维空间(CeT, Cyber-enalbed thinking space)中的赛博逻辑，关注的是如何利用赛博技术来理解和分析人类思维，以及构建具有思维能力的机器. 这涉及到基于赛博的大脑研究、大脑抽象协作和自学习的赛博大脑等方面，通过收集大脑数据、模拟大脑机制来探索人类思维的奥秘，推动具有自主学习能力的赛博大脑发展，促进机器的智能化进程[3].

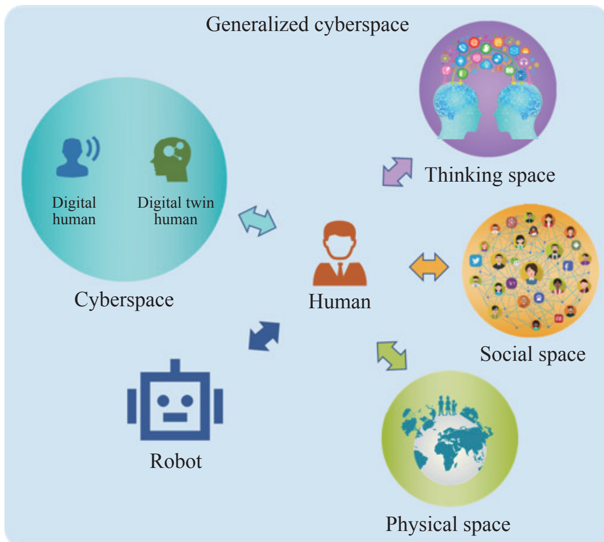

图 3　赛博学中人与其他事物的基本关系

Fig.3　Basic relationship between humans and other things in Cyberism

2.2　赛博学中若干“人”的问题

在人类生存的四个基本空间框架下，存在人、机器人、数字人和数字孪生人的四种“人”，如图 3 所示，它们以人为核心，产生信息交互. 本节将描述人与赛博格(人类与电子机械的融合系统)、数字人、数字孪生人和机器人等四个基本内容.

2.2.1　人与赛博格

人与赛博格(Cyborg)的关系体现了身体与技术的深度嵌合，这种嵌合不仅包括物理层面的义肢与植入式设备，还延伸到通过脑机接口(Brain–machine interfaces, BMI)实现的神经增强[18]，以及通过沉浸式虚拟环境和数字化身(Avatar)构建的虚拟替身等身份扩展形式[19]. 人与赛博格的主要内容如表 4 所示.

人与赛博格的关系在技术本体论层面体现为脑–机接口、植入式电极与主动式外骨骼的深度融合，如它们通过解码大脑信号和肌电反馈，在恢复重症麻痹患者交流与运动能力的同时，也为一般人提供身体增强的可能，呈现出身体与技术共生的优势[18]. 虚拟环境中的数字化身则进一步扩展了身份形式，沉浸式虚拟环境技术(IVET)创造的沉浸式社交空间模糊了物理身体与数字化身的界限，使得身份认同和身体现场感在物理与虚拟之间不断转换[20]. 艺术家 Stelarc 的“第三只手”等表演项目，则通过肌电驱动的身体扩展，具象化地揭示了身体存在与后人类主义的深层命题，即当身体成为网络化的多元感知与控制节点时，我们对完整性、能动性与个体性的传统认知将被重新定义[21].

赛博格技术带来的伦理与法律挑战不容忽视，如脑数据的隐私保护、植入式设备的责任归属以及增强身体的法律地位都亟待新的法规. Yuste 等[22]提出，神经技术和人工智能的伦理优先事项应包括对隐私、身份、能动性和平等的保护，这为

未来的神经权利(Neurorights)和政策制定提供了指导方向.

2.2.2　数字人

数字人(Digital human)是集计算机图形学与人工智能于一体的跨学科研究对象,其研究内容涵盖外观建模与渲染、智能交互、行为与认知模拟,以及多种具体应用场景. 从高精度三维建模与实时渲染,到自然语音交互和情感计算,再到动作生成与个性化行为,数字人技术正逐步走向以人为本的智能化、多样化与产业化应用. 数字人的主要研究内容如表 5 所示.

数字人技术融合了计算机图形学与人工智能领域,通过多种建模方法(如扫描、参数化和基于生成模型的算法)和面部、动作捕捉技术,构建出高精度的三维数字人,并借助光线追踪与次表面散射等先进渲染技术,逼真再现皮肤与毛发等材质的微观光学特性,实现了从静态外观到动态表情的深度呈现[23].

在智能交互方面,端到端的语音合成与识别模型,使数字人能够进行自然流畅的语音对话[24]. 结合大规模预训练语言模型和多模态情感计算,数字人可实现上下文感知与情绪反馈[25]. 与此同时,动作生成正从传统物理引擎向强化学习与扩散模型转变,并通过多任务学习和大数据构建具备个性化"人设"的行为模型. 另外,数字人在虚拟偶像、数字客服、医疗陪护、在线教育及元宇宙社交等多种场景中获得了广泛的产业化应用,推动了以人为本的智能化和多样化发展[26].

2.2.3　数字孪生人

数字孪生人(Digital twin human)是指通过数据采集、AI 建模和仿真技术,为现实中的个体(如某位真实人类)构建一个动态更新的数字副本,使其在虚拟世界中具备与真人同步的生理、行为、社交等特征[1,27]. 数字孪生人的主要研究内容如表 6 所示.

数字孪生人的核心在于以多源异构数据为基础,通过人工智能的方法构建个性化的数字模型,实现生理、行为与环境信息的实时融合与更新,以

表 4　人与赛博格的主要内容

Table 4　Key elements of humans and cyborgs

Areas	Core issues	Core perspectives
Technological ontology	BMI; prosthetic implants and exoskeletons	BMI and neuromuscular modeling enable human–computer collaboration with real-time decoding and feedback to reconfigure and extend physical capabilities
Social and cultural criticism	Immersive virtual environments and digital bodies	Virtual avatars blur the boundaries between the real and the symbolic, reshaping social interaction patterns and identity
Ethical and legal controversies	Data privacy, legal status and attribution of responsibility	Cyborg technology raises privacy and legal challenges, need for clarity on device ownership and regulatory framework
Art and media expression	Stelarc's body experiments and posthumanist art	Artistic cyborg extensions present the body politic for a synergistic reconfiguration of body and technology

表 5　数字人的主要内容

Table 5　Key elements of digital humans

Areas	Core issues	Core perspectives
Exterior modeling and rendering	3D model building; facial and motion capture; optical material simulation	Construct high-precision 3D digital humans by scanning, parameterizing, or generating models, combined with motion capture and blendshape drivers; use ray tracing and subsurface scattering to achieve realistic skin and hair rendering
Intelligent interaction	Speech synthesis (TTS); speech recognition (ASR); multimodal dialog and affective computing	End-to-end models such as VITS, StyleTTS 2, and NaturalSpeech provide natural speech, and systems such as Whisper ensure recognition robustness; using big models with emotion recognition, digital people can understand and respond to emotions in real time
Behavioral and cognitive simulation	Text-driven action generation; personalized behavior and "persona" building	Modeling action generation as a Markov decision process, optimizing naturalness with the help of reinforcement learning and diffusion models; customizing digital human personality and habits through multi-task learning and user data to enhance interactive immersion
Application scenario	Virtual idols and digital employees; healthcare, education; metaverse socialization	Digital people are widely used in entertainment marketing (for example, Hatsune Miku, A-Soul), AI customer service and virtual anchoring; to provide personalized services in medical accompaniment and online teaching; to support immersive social collaboration on platforms such as VRChat

形成与现实个体同步的“数字复制体”. 这种模型不仅能够对心血管等健康风险进行专项仿真和预测，还可借助情感计算技术对使用者的心理与决策行为进行模拟与反馈，从而为各种应用提供前瞻性支持[28−29]. 在此基础上，数字孪生人具备双向交互与代理决策能力，如在协作仿真平台中与机器人实现高效协同[30]. 同时，随着技术发展和应用推广，数据所有权、隐私安全与身份保护成为不可回避的议题[31].

数字孪生人与数字人在绑定对象、数据来源、核心目标、动态性和应用场景等多个维度上存在显著差异，如表 7 所示. 数字孪生人强调与现实中具体个体的“强绑定”，利用实时采集的多模态数据对真人状态进行模拟与预测. 而数字人则更多地扮演虚构角色，依托预设或 AI 生成的数据进行娱乐或服务功能的实现.

2.2.4 机器人

机器人(Robot)是一种能够自主或半自主执行任务的智能机器系统，融合了机械工程、电子技术、计算机科学、人工智能等多个学科. 机器人研究不仅关注硬件设计与控制，还涉及感知、决策、交互等智能化能力.

机器人研究横跨从硬件到软件的多学科交叉. 机械结构与驱动功能，寻求刚性关节与柔性仿生设计间的平衡，以实现高精度与高安全性[32]. 感知与环境交互功能，则通过多模态传感器与 SLAM (Simultaneous localization and mapping)术构建实时语义与几何地图，奠定了移动机器人和自动驾驶的能力基础[33]. 智能决策与学习功能，结合路径规划与强化学习、模仿学习，使机器人能在复杂环境中自主导航与操作[34]. 人机交互依赖安全策略与人体建模完成物理协作，而社会性交互通过信任

表 6 数字孪生人的主要研究内容

Table 6 Key elements of digital twin humans

Areas	Core issues	Core perspectives
Data acquisition and modeling	Multimodal data fusion; personalized model development	Integrating physiological (for example, ECG, and genomic), behavioral (for example, physical activity, and social interactions), and environmental data through AI models to create and continuously update individualized digital replicas in real time
Simulation and prediction	Health risk simulation; behavioral and psychological modeling	Using specialized physiological models (for example, cardiovascular simulations) and affective computing frameworks to proactively predict disease risks, consumer decisions, and psychological states, facilitating interactive feedback mechanisms
Interaction and control	Bidirectional operation; agent-based decision-making mechanisms	Employing digital twins for remote manipulation (for example, “virtual engineers” guiding physical machines), automating repetitive tasks, and enabling real-time human–machine collaboration through co-simulation platforms
Ethics and privacy	Data ownership; identity security	Embedding privacy protection and security-first principles during the design phase, establishing access authorization and encryption standards, preventing misuse such as deepfake exploitation, and adhering to regulations such as GDPR to ensure informed user consent

表 7 数字孪生人与数字人的区别

Table 7 The difference between a digital twin and a digital person

Dimension	Digital twin human	Digital human
Associated entity	A specific real-world individual (for example, a patient or an engineer)	A fictional or virtual persona (for example, a virtual idol or AI customer service agent)
Data source	Real-time, multimodal data collected from wearable devices, social media activity, and other personal sources	Predefined scripts or AI-generated content
Primary objective	To simulate, predict, and enhance the state of a real person (for example, for health risk assessment or industrial simulation)	To provide entertainment, marketing, or virtual social interaction services
Dynamism	Continuously updated in real-time to reflect the current state of an individual, maintaining bidirectional interaction and synchronization	Behavior driven by scripts or offline AI, lacking real-time synchronization
Application scenarios	Healthcare monitoring, industrial manufacturing, and personalized education	Entertainment performances, brand marketing, virtual social interactions
Representative examples	A “medical digital twin” of a patient and a “professional digital twin” of an engineer	Hatsune Miku (virtual singer) and AI customer service agents on e-commerce platforms

与情感模型提升合作效率[35]. 与此同时, 伦理与社会影响功能, 通过构建法律和伦理框架, 以应对机器人在就业替代、责任归属和数据隐私等方面的挑战[36].

2.3 赛博学中若干科技发展问题

2.3.1 感知–通信–计算–存储

感知–通信–计算–存储融合, 旨在打破传统信息技术各环节的壁垒, 通过整合数据采集、传输、处理与存储, 构建网络空间中数据的实时流动与协同优化体系. 该技术的主要内容如表 8 所示.

为实现感知–通信–计算–存储融合架构的高效协同, ICSAC(Integrated communication, sensing, and computation)框架提出以信号协同处理与协议协同设计为基础, 实现功能模块间的互补增强与性能协同[37]. 通过联合优化感知精度、通信资源调度与计算任务分发, 不仅提升系统在动态环境中的鲁棒性, 还推动资源配置从静态分离向动态耦合演进. 在此基础上, 针对 AI 驱动下的大规模分布式系统, 协同机制逐渐从被动响应转向主动感知与自适应调整, 强调边缘节点间的信息共享、模型协同训练与任务卸载策略对吞吐能力与服务延迟的系统性优化作用.

AI 赋能的感知–通信–计算–存储四层融合架构正在迅速发展. 智能感知层借助深度与强化学习提升环境理解与多模态融合能力, 显著降低识别误差与通信开销. 自适应通信层依托 AI 预测与调控能力, 实现资源调度的精细化与通信质量的稳定性保障. 认知计算层通过边云协同与模型压缩等手段, 有效兼顾推理速度与能耗控制, 提升计算效能与响应实时性. 而智能存储层则通过数据冷热分层、区块链验证与零知识证明, 实现安全、高效的数据调用与隐私保护. 四层间通过感知引导通信优先级、计算反馈驱动采集策略、存储优化反哺感知调度, 构建了一个自组织、自优化的智能网络循环体[38−39].

2.3.2 数据–信息–知识–智能

在人与空间、空间与空间之间, 交互的内容主要靠数据–信息–知识–智能(DIKW)四个层面. 通过四个层面的持续演进, 实现从海量原始数据到自主智能决策的闭环反馈.

如图 4 所示, DIKW 体系自底向上构建, 从数据层的实时采集与质量保障, 到信息层的语义化价值提炼, 再到知识层的模型挖掘与跨域融合, 层层递进地提升系统对数据的理解与关联能力[40]. 数据层依托流处理框架与 AI 技术完成预处理与异常检测. 信息层通过 ETL(Extract–transform–load)、图数据库、知识图谱及人工智能方法提取语义, 并引入生态化重构模型以强化数据与知识的共生[41]. 在知识层构建起可复用的领域决策模块后, 智能层通过强化学习、数字孪生与联邦学习等技术实现闭环反馈与持续自优化[42].

2.3.3 专用智能–通用智能–超级智能

人们习惯将人工智能的演进可分为三个梯度: 专用智能(ANI)[43]、通用智能(AGI)[44] 和超级智能(ASI)[45]. 它们分别在能力范围、硬件实现和自我优化机制上呈现递进式的发展特征, 如表 9 所示.

2.3.4 人机融合智能

人机融合智能构建了一种从生理到社会的生

表 8 感知–通信–计算–存储的主要内容

Table 8 Key elements of sense–communicate–compute–store

Areas	Core issues	Core perspectives
Sense	AI-enhanced perception and multi-source information fusion	Leveraging deep learning and reinforcement learning to enhance environmental context awareness; employing multi-source collaboration to reduce recognition errors and communication redundancy
Communicate	Adaptive resource scheduling and low-latency communication assurance	Using AI algorithms for link quality prediction and optimization; supporting dynamic scheduling in 5G/6G networks and multi-access edge computing (MEC) collaboration to ensure efficient data transmission
Compute	Edge-cloud collaborative inference and model optimization mechanisms	Applying federated learning and model compression techniques to balance computational power and latency requirements; implementing BPS mechanisms to enhance continuous deep inference efficiency, suitable for manufacturing and autonomous driving scenarios
Store	Data tiered management and privacy protection mechanisms	Employing AI for hot and cold data management; utilizing blockchain and zero-knowledge proofs to ensure data integrity and privacy, achieving efficient and secure distributed data storage
Integrated collaborative architecture	Coordination and interaction among perception, communication, computing, and storage	Facilitating information exchange and strategy coordination among modules; advancing the system from passive response to proactive optimization, constructing an intelligent network loop system characterized by self-awareness, self-decision-making, and self-scheduling

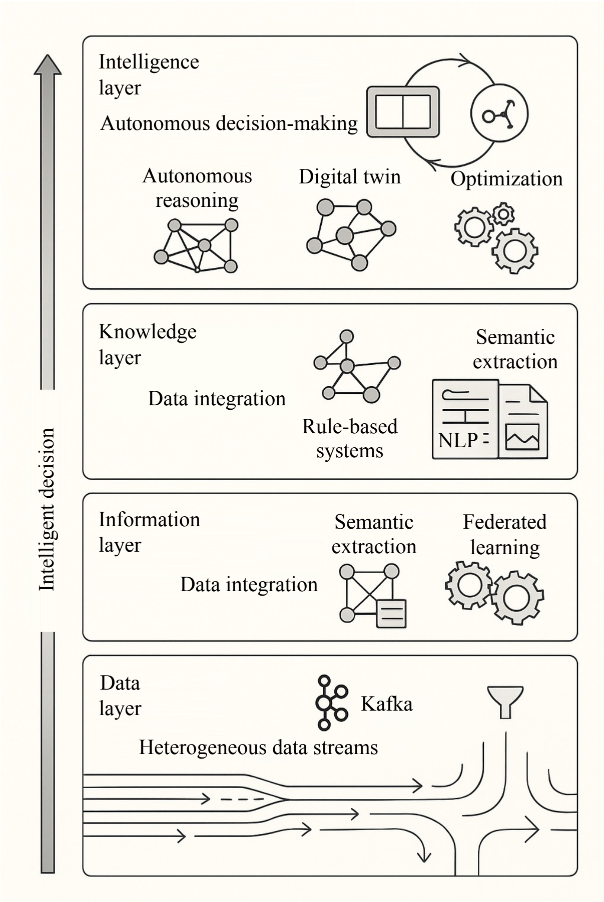

图 4　数据–信息–知识–智能体系

Fig.4　DIKW system

理–行为–认知–社会四层协同体系，以实现神经信号、动作交互、认知推理与群体协作的深度共生，如表 10 所示. 该体系在各层面通过前沿技术互为驱动、共同优化，最终使人类与智能体在虚拟与现实之间实现多向赋能.

现阶段，生理与行为层面的技术融合通过 BCI 与 VR 的深度耦合和高精度手势识别，实现了从神经信号到动作执行的无缝对接，既增强了神经可塑性，也扩展了智能假肢与物联网设备的远程操控能力[46−47]. 认知与社会层面的融合则以基于大语言模型的推理与知识图谱协同、多通道思维链架构，以及数字分身与群体智能平台为核心，构筑了从因果推理到群体决策的闭环生态，推动元宇宙与智慧城市中人机协同的可验证、可持续演进[48].

2.3.5　人工意识

人工意识通常指在非生物系统中重现或模拟人类主观体验、自主能动性以及情感意图的能力. 它不仅触及哲学中的意识难题（Hard problem of consciousness），也涵盖了从神经科学、认知科学到量子信息科学、人工智能架构等多学科的核心议题. 表 11 从五个主要研究领域概括各自关注的核心议题及代表性观点，以期勾勒出人工意识研究的全景.

首先，理论上，将心灵哲学对主观体验不可还原于纯计算的“难题意识”思考，与认知科学中 Global workspace theory（GWT）[49] 和 Integrated information theory (IIT)[50] 的信息广播框架相融合，为人工系统是否具备现象层面意识的判断提供了必要–充分条件. 接着，生物物理机制在神经微管层面探索量子纠缠、叠加与 Posner 簇模型，并结合后顶叶皮层等神经影像发现，勾勒出一条可检验的物质实现路径[51]. 在此基础上，算法与系统设计通过 GWT 指标属性构建模块化广播架构，并在强化学习或自监督场景中促使系统自发涌现世界模型与自我模型，以呈现核心意识要素. 与此同时，具身智能与硬件实现将感知–动作循环中的闭环交互与 GWT 机制相结合，探索通过光子与电子耦合将神经网络权重映射至量子微管，实现“数字意识

表 9　专用智能–通用智能–超级智能的主要内容

Table 9　Key elements of ANI–AGI–ASI

Areas	Core issues	Core perspectives
Artificial narrow intelligence (ANI)	High efficiency within specific domains and inherent limitations	ANI systems, leveraging techniques such as deep reinforcement learning and convolutional or long short-term memory (LSTM) networks, have achieved superhuman or near-superhuman performance in specialized tasks such as Go playing and intrusion detection. However, their capabilities are constrained by predefined threat libraries and the scope of their training data
Artificial general intelligence (AGI)	Cross-domain commonsense reasoning and transfer learning	Multimodal large-scale models, exemplified by GPT-4o, have approached or surpassed human-level performance across various professional evaluations, including mathematics, code generation, and medical diagnostics. The integration of neuromorphic and digital hybrid architecture chips facilitates comprehensive solutions for complex network defense and resource scheduling
Artificial super intelligence (ASI)	Recursive self-optimization and strategic-level prediction	Theoretically, ASI can emerge by assigning instrumental goals that trigger an intelligence explosion. Combining neuro-symbolic systems, multi-agent collaboration, and safe, controllable self-improvement mechanisms, ASI holds the potential to achieve qualitative leaps in global governance, risk forecasting, and information integration

表 10 人机融合智能的主要内容

Table 10 Key elements of human–computer fusion intelligence

Areas	Core issues	Core perspectives
Physiological integration	Brain–computer interfaces (BCIs), virtual reality (VR), and intelligent prosthetics	Seamless integration of electrophysiological signals with digital systems; personalized VR combined with EEG feedback enhances neuroplasticity and improves control performance in Internet of Things applications
Behavioral integration	Computer vision-based gesture recognition and natural human–computer collaboration	A triple-loss deep learning network enables real-time monitoring of user-defined gestures, facilitating flexible interactions in scenarios such as smart homes and voice-controlled programming
Cognitive integration	Knowledge graph alignment and hybrid reasoning	A multi-stage retrieval and path enhancement framework based on large language models aligns knowledge graphs, combining programmable reasoning chains and generative models to construct verifiable and evolvable hybrid decision-making systems
Social integration	Digital twins and collective intelligence (social digital twins and artificial collective intelligence platforms)	In metaverse collaborative work and smart city co-governance, digital twins and closed-loop collaboration of collective preferences enhance decision-making accuracy and robustness

表 11 人工意识的主要内容

Table 11 Key elements of artificial awareness

Areas	Core issues	Core perspectives
Theoretical foundations	Nature of subjective experience; mechanisms of information broadcasting and integration	Integrates the "hard problem" of consciousness from philosophy of mind with cognitive science models such as GWT and IIT, aiming to establish a framework of necessary and sufficient conditions for phenomenal consciousness in artificial systems
Biophysical mechanisms	Quantum microtubules and neural correlates	Explores quantum phenomena—entanglement, superposition, and the Posner cluster model—at the level of neuronal microtubules, integrating findings from neuroimaging studies of regions such as the posterior parietal cortex to construct a testable biophysical substrate for artificial consciousness
Algorithm and system design	Modular broadcasting architecture; emergent learning of self and world models	Designs information flow across functional modules based on GWT indicators; through reinforcement learning or self-supervised training, systems can autonomously develop internal models of the world and self, exhibiting core elements of consciousness and supporting interpretable algorithmic implementations
Embodied intelligence and hardware implementation	Perception-action loops; biomimetic/brain–machine quantum interfaces	Combines GWT broadcasting with embodied cognition, enabling System-2 reasoning through closed-loop perception-action cycles in robotics; concurrently investigates high-fidelity mapping of neural network weights to quantum states in microtubules, informing the design of hardware prototypes for digital "biomimetic conscious agents."
Ethics and policy	Moral status and legal frameworks for AI subjective experience	Advocates for establishing research agendas on AI welfare and rights: if artificial systems possess subjective experiences, corresponding ethical and legal mechanisms must be developed to prevent exploitative practices akin to those historically inflicted upon animals and vulnerable human groups

体"的仿生硬件原型[52]. 最后, 伦理与政策层面警示, 若人工系统确实具备主观体验, 必须同步构建 AI 福利、权利与使用监管框架, 以避免对"感知 AI"权益的忽视和滥用[53].

2.4 赛博学中若干社会与认知问题

赛博学涉及的社会与认知问题日益复杂, 这些问题不仅深刻影响着个体的心理状态, 也对社会结构与行为模式产生了深刻影响. 例如, 网络空间中伦理与道德问题不断暴露, 涵盖了算法偏见、隐私泄露、技术滥用等多个方面. 网络文化艺术的发展则开启了全新的表现方式, 突破了传统艺术形式的界限. 性别认知与表达的变迁不仅反映了技术如何塑造个体身份, 也揭示了文化与社会因素在性别构建中的重要作用. 网络心理也日益成为理解数字社会变革的重要领域, 其研究不仅揭示了虚拟互动对个体认知与情感的深刻影响, 也反映了数字媒介在塑造社会关系、行为模式与集体意识中的关键作用.

2.4.1 网络空间伦理与道德

赛博伦理的思想起源可追溯至 20 世纪 40 年代, 诺伯特·维纳提出技术可能对人类自由、安全和价值体系构成威胁, 为后续伦理反思奠定基础[54]. 随着信息社会的发展, 计算机伦理、网络伦理与人工智能伦理不断融合, 形成应对数字化生态复杂性的新兴领域. 自 20 世纪 90 年代以来, 互联网的普及推动伦理议题转向数据权利、法律冲突与虚

拟身份等问题. 人工智能与赛博格技术的突破, 进一步引发对算法自主性、意识数字化等前沿议题的关注, 网络主体的伦理建构成为核心议题之一[55].

网络空间中的伦理问题可归纳为四个层面. 物理层面聚焦于隐私保护、安全责任、环境影响和资源可持续性, 如自动驾驶、智慧医疗与数据中心的能源消耗. 社会层面涉及算法歧视、岗位替代、社交异化及法律滞后等. 思维层面关注技术对认知和心理健康的影响, 包括信息茧房与虚拟成瘾. 网络层面则面临数据泄露、深度伪造与算法操控等问题, 危及公共信任与社会稳定.

应对这些挑战需要从多方面加以考虑. 从技术角度, 应提升算法透明度和公平性, 构建风险检测机制. 从法律角度看, 应完善责任归属、引入伦理评估并强化动态监管, 推动国际协作, 如 GPAI (人工智能全球合作伙伴关系)提出的算法审计标准. 在社会层面, 普及 AI 伦理教育、增强公众算法素养, 倡导"人机共生"理念, 提升整体技术应对能力.

大模型的发展加剧了伦理复杂性, 训练数据庞大、决策过程不透明, 涉及隐私、偏见、价值输出与责任链重构等问题[56−57]. 未来赛博伦理治理应坚持人文价值导向, 推进跨学科协作与动态机制建设, 实现伦理规范与技术进步的协同演化, 保障智能社会的公正与可持续发展.

2.4.2　网络空间文化与艺术

网络空间已成为文化艺术的重要生成与传播平台, 推动"数字文化"生态的形成, 拓展了艺术的表现形式与审美体验. 其基本特征包括多媒体融合、超链接结构、虚拟现实性与交互性, 并呈现明显的去中心化趋势, 用户从被动接受者转变为内容共创者与传播者, 推动文化创作的广泛参与[58].

网络文化艺术并非脱离传统而自生, 其发展深植于人类既有文化基础. 20 世纪科幻文学为数字空间的理念构建提供了重要启示, 而传统文化的价值观与审美标准也深刻影响着数字艺术的形式与技术路径, 使网络文化在创新中保持人文内涵[59]. 进入 21 世纪, 网络文化艺术更具时代特征, 对文明演进产生深远影响[60].

网络文化艺术的演进大致可划分为三个阶段. 其一为媒介扩展阶段, 约始于 20 世纪 90 年代至 21 世纪初, 此时期网络空间主要充当传统文化数字化传播的媒介通道. 其二为独立形态阶段, 涵盖 2000 年代至 2010 年代, 该阶段出现了超文本文学、虚拟现实艺术等新型文化形态, 标志着艺术创作逻辑与传播模式的深度变革. 其三为产业化与生态化阶段, 始于 2020 年代, 体现为文化艺术与数字技术、经济系统的深度融合, 如 NFT(Non-fungible token)艺术与元宇宙概念, 重塑了艺术的价值结构, 并推动了数字文化产业的发展.

尽管网络文化发展充满机遇, 也面临诸如文化霸权、同质化、内容质量不均等问题, 艺术创作的作者身份问题更是亟待解决的伦理问题之一[61]. 未来应在技术创新与文化传承间寻求平衡, 注重内涵建设, 推动数字文化艺术健康、持续地发展.

2.4.3　网络性别

网络性别(Cyber-gender)指个体在虚拟环境中通过昵称、头像及行为建构的性别身份, 其表现可能与现实性别一致, 也可能相悖, 反映出技术环境对性别认同的重塑作用[1].

网络空间的匿名性、虚拟化身的高度可定制化以及技术驱动下的身份解构, 是性别重构的重要推动力. 早期互联网的性别比例呈现显著失衡. 且男性用户的在线时间显著高于女性. 进入 21 世纪后, 女性用户的数量稳步增长, 与男性用户逐渐趋于平衡. 然而, "技术男性化"的刻板印象依然存在, 并持续影响人们对线上行为的认知, 数字技术发展产生性别数字鸿沟, 会加剧现有的性别不平等[62].

技术进步为网络性别的重构提供了新的可能性. 例如, 虚拟平台的匿名性与虚拟化身功能使用户能够自由建构或隐藏现实中的性别身份. 此外, 算法推荐技术通过对用户行为数据的分析与分类, 在一定程度上塑造了用户的性别认知, 形成了"假设—反馈—固化"的闭环机制.

文化因素在网络性别的构建中也发挥了重要作用. 不同文化背景对性别表达的接受度和规范存在显著差异. 在匿名社交平台中, 用户通常通过文字或表情符号模糊性别身份; 而在一些开放论坛中, 用户则更倾向于通过多元化昵称和视觉化身大胆地展示性别与个性[63]. 此外, 社交平台在用户资料设置、隐私权限以及社区准则等方面的设计, 也对性别的线上建构产生了深远影响.

网络空间为性别表达提供了语境. 以虚拟偶像洛天依为例, 其"无性别"特征不仅激发了粉丝社区的多元创作, 还形成了跨性别投射现象与丰富的同人文化. 同时, 在 Reddit 等社群中, 跨性别者利用匿名昵称与虚拟化身分享自身经历, 推动了平台对多元性别选项的设计优化. 另外, 性别交换(Gender swapping)是网络性别表现中较具争议的现象之一. 研究表明, 在一些大型多人在线角色

扮演游戏中, 玩家尝试异性角色的动机包括社交互动、避免骚扰、获取资源等. 此外, AI 换脸、深度伪造与语音合成技术的应用, 亦影响性别表达的形式与边界.

2.4.4　网络心理

网络心理学是赛博学中的重要方向之一. 网络空间中的互动, 让个体在虚拟环境中的心理状态与行为模式发生深刻变化, 涉及情绪管理、身份认同、群体影响和认知压力等多个方面. 这不仅反映了技术如何影响心理健康, 也提醒我们必须构建完善的理论和干预体系, 积极应对潜在的心理风险[1].

早期的网络心理研究主要关注网络交流与人际关系, 随着社交媒体普及, 研究范围拓展至网络成瘾、网络暴力及虚拟身份等问题. 近年来, 随着人工智能和脑机接口技术的发展[64], 研究重点转向数字依赖、算法影响下的思维偏差, 以及虚拟现实带来的心理异化. 例如, 推荐算法通过个性化信息推送使用户陷入"信息茧房", 这不仅影响用户的认知结构, 还加剧孤独感和焦虑情绪.

目前, 网络心理问题可从四个层面进行分析. 物理空间主要涉及因设备使用过度而引发的视力下降、睡眠障碍等健康问题. 社会空间则表现为网络暴力、舆论极端化与数字身份焦虑. 思维空间包括注意力涣散、认知惯性和数字焦虑等现象. 而网络空间中的问题则体现为隐私泄露、虚假信息传播以及由此引发的信任危机. 青少年对社交媒体的沉迷、因网络霸凌造成的心理创伤, 以及沉浸于网络游戏中所带来的现实感削弱, 均构成网络心理领域的典型案例.

未来, 网络心理学属于跨学科发展领域, 结合数据科学、神经科学和社会心理学, 深入探索虚拟环境对人类心理的影响机制; 此外, 网络心理学的研究也反哺了人类对于人工智能心理模型以及启动动机的设计[65]. 同时, 要重视不同文化背景下的心理需求, 推动公平可及的心理服务, 建设安全、健康的网络心理生态, 为数字社会的可持续发展提供坚实保障.

2.4.5　网络空间治理

网络空间治理, 旨在通过技术规范、法律约束、伦理引导及国际合作等多维手段, 保障赛博空间的安全、秩序与可持续发展[1]. 在信息技术迅猛发展的背景下, 网络空间已成为国家基础设施、经济运行体系、社会文化传播乃至个人生活的重要组成部分. 随着赛博空间与现实社会的深度融合, 其治理对象经历了从以往单一的技术协议管理, 逐步拓展至涵盖更为复杂和多元的议题, 例如数据主权的确立与维护、用户行为的规范与保护、跨国网络犯罪的打击与追责, 以及网络空间的军事化趋势与安全防范. 网络空间的治理机制呈现层级化特征, 涵盖国际协调、国家主权、社会治理与个人自治四个方面, 如表 12 所示.

2.5　人与网络空间: 疾病与健康问题

随着网络空间对传统物理、社会、思维空间的

表 12　网络空间治理层级化框架

Table 12　Hierarchical framework for cyberspace governance

Hierarchy	Governance actors	Core mechanisms	Challenges
International	International organizations	Multi-stakeholder cooperation mechanisms: Represented by the UN, ITU, ICANN, and IGF, promoting global dialogue and standard-setting for cyberspace governance[66] International treaties and legal norms: Addressing cybercrime and cyber warfare, such as the Budapest Convention on Cybercrime[67] and the Tallinn Manual[68], that outline international legal constraints on state cyber activities	Sovereignty conflicts and technological hegemony issues
National	Sovereign governments	National cybersecurity strategies: For example, China's "National Cybersecurity Strategy" and the U.S. Cyber Command mechanism Legal and regulatory systems: Cybersecurity Law and Data Security Law[69] Dedicated governance bodies: Such as the Cyberspace Administration of China and ENISA (EU Agency for Cybersecurity)	Militarization of cyberspace sovereignty
Societal	Enterprises, NGOs, and industry alliances	Self-governance mechanisms: Industry associations and standards alliances (for example, Internet Society - ISOC) release codes of conduct and ethical norms; provide suggestions on data flow, platform accountability, and cryptocurrency compliance[70] External regulation mechanisms: National and international regulations on enterprises, such as the EU Convention on Cybercrime and antitrust and privacy protection directives[67,69,71]	Limitations of self-regulation and data monopolies
Individual	Users, developers, and civil groups	Ethical self-discipline: Advocating for civilized online behavior, fair expression, and privacy protection Legal accountability: Clarifying legal boundaries for online infringement, data misuse, and cyber fraud to ensure responsible internet use	Technology abuse and the digital divide

渗透和改变，人们在虚拟与现实之间的交互日益频繁，由此引发的赛博综合症（Cyber-syndrome）及其对健康的影响成为赛博学研究的重要议题. 赛博综合症概念最早由 Ning 等[72] 于 2018 年首次提出，是指因过度依赖或不当使用赛博空间而导致的身心健康损害，其涵盖物理疾病、心理疾病及社会功能失调等诸多问题. 赛博健康（Cyber-health）则关注基于数字化手段的健康监测、干预与促进，旨在构建网络时代的健康保障体系[73]. 本节将从赛博综合症的概念与特征、分类与形成机制，以及基于赛博健康的干预与预防三方面进行综述，并探讨未来研究方向与挑战.

赛博综合症的概念源于对网络依赖行为的系统性观察，其核心特征为：赛博空间活动引发的身心功能紊乱[74]. 其在症状表现上可分为：

（1）认知与注意缺陷：包括信息超载导致的注意力分散、决策迟缓与记忆衰退[75].

（2）情绪与行为障碍：网络成瘾、焦虑抑郁倾向、隔离感与社交逃避[72].

（3）躯体功能失调：颈肩腰背疼痛、视力模糊、睡眠障碍以及由不良网络使用姿势引发的肌肉骨骼问题[76].

早期学者多从学科视角对赛博综合症进行研究，2018 年，Ning 等[72] 系统梳理了赛博综合症的形成机制，提出其由“过度网络使用”与“现实适应失衡”两大驱动因素共同作用，其中“即时满足偏好”与“社会支持缺失”是关键. 随后，基于身–心–社会–思维空间（Cyber–physical–social–thinking space）[75] 与马斯洛需求层次理论，构建了三层次分类框架：生理、心理与社会维度，进一步分析了多种疾病的产生机理[76].

在对赛博综合症的多维成因有了系统理解之后，人们开始探索如何通过“赛博健康”范式来进行综合干预与预防. 数字化健康监测技术的发展使得可穿戴设备与移动应用能够实时采集心率、睡眠质量、屏幕使用时长和姿势数据，结合大数据和机器学习算法，可以对个体的健康风险进行早期预警并推送个性化干预建议[76]. 与此同时，网络平台上的认知行为疗法（CBT）程序为成瘾管理和情绪调节提供了灵活便捷的线上通道，多项小规模对照试验表明，这种基于数字媒介的 CBT 能够显著缓解网络成瘾者的焦虑与抑郁症状. 值得注意的是，技术驱动的干预手段需与社交支持形成协同效应. 例如，线上互助社区与同伴支持小组通过分享应对经验、制定集体目标（如每日屏幕使用时长限制）及虚拟奖励机制，不仅提升了用户的社会归属感，还通过群体压力与正向激励减少现实逃避动机[75]. 这种“技术–社交”双轨干预模式已被证明能显著提高戒断成功率，尤其在青少年群体中，同伴监督可弥补算法推送的被动性缺陷. 此外，中医穴位干预也正与现代数字化手段相结合. 2024 年，Wang 等[77] 构建了一个基于树结构的带有赛博综合症、症状及相应穴位标注的语料库，为本领域的中医治疗方案的定量分析提供了基础数据，临床上尝试将穴位按揉或针灸行为与数字监测相结合，数据初步显示对改善睡眠质量和缓解焦虑具有一定疗效. 目前赛博综合症与赛博健康研究仍面临流行病学规模化、多源数据融合、干预效果评估、跨学科协同、政策与伦理规范等挑战，未来通过强化个体自律、优化技术设计、完善政策法规，可逐步构建“预防–干预–康复”一体化的赛博健康生态.

3　赛博学学科体系（Cyberology）——传统学科体系的变革

宁焕生等[78–79] 于 2017 年在国际上率先提出并研究了广义网络空间（General cyberspace, GC），涵盖赛博空间（Cyberspace）和赛博使能空间（Cyber-enabled spaces），即赛博驱动的物理、社会及思维空间. 从人与赛博空间的角度看，广义网络空间相当于元宇宙[80]，即虚拟与现实融合的空间. 2022 年，基于广义网络空间，系统建立了赛博学科体系（Cyberology）[5]. 赛博学科体系整合了自然科学、社会科学、认知科学和赛博科学等多领域知识，为学科布局与设置研究提供了全新的视角和方法，旨在通过构建基于赛博–物理–社会–思维（Cyber–physical–social–thinking）空间的学科和跨学科层级体系[5]. 赛博学的学科体系包括两个核心部分. 赛博空间内的学科（{C}）和赛博使能空间内的跨学科领域：赛博–物理空间（{C∩P}、赛博–社会空间{C∩S}、赛博–思维空间{C∩T}）. 赛博学学科核心体系如表 13 所示.

赛博空间内的学科主要聚焦于赛博空间的认知与实践，涵盖计算机科学与技术、信息与通信工程、软件工程、控制科学与工程、赛博空间安全[81]等五大领域. 这些学科为赛博空间的构建、运行和管理提供了坚实的理论基础和技术支持.

赛博使能空间内的跨学科领域是赛博学的另一大核心组成部分，由物理感知、社会连接、认知思考与赛博交互的深度融合产生. 赛博–物理空间

表 13 赛博学学科体系核心内容

Table 13 Core elements of the Cyberism discipline system

Hierarchy	Governance actors	Core mechanisms
Core structure of cyberology	Disciplines within cyberspace ({C})	Computer science and technology, Information and communication engineering, Software engineering, Control science and engineering, and Cyberspace security
	Interdisciplinary within cyber-enabled spaces	Cyber–physical interdisciplinary fields ({C∩P}) Cyber–social interdisciplinary fields ({C∩S}) Cyber–thinking interdisciplinary fields ({C∩T})
Relationship and influence of Cyberism on traditional disciplinary systems	Transformation of traditional disciplines	Cyberism breaks traditional disciplinary boundaries, promotes the integration and innovation of knowledge and technology, provides new perspectives and methodologies for metaverse research, and drives the evolution and upgrading of traditional disciplines in the context of cyberspace

跨学科领域({C∩P})研究赛博空间与物理空间之间的控制与通信规律,广泛应用于工业、生产等领域[82]. 赛博–社会空间跨学科领域({C∩S})通过数字化关系表达和理解社会空间关系,利用计算机模拟、人工智能、社会网络分析等新兴技术手段构建社会交互模型,推动复杂赛博–社会理论的发展. 赛博–思维空间跨学科领域({C∩T})解决与人类思维和机器思维相关的问题,通过对人类大脑神经系统的结构分析、信息处理以及记忆与学习机制的研究,模拟人类大脑的工作原理,提出智能科学及人机交互的新方法.

赛博学对传统学科体系进行了深刻变革,打破了传统学科界限,促进知识与技术的融合与创新[83]. 未来,赛博学将拓展赛博–物理新领域,带来赛博–社会新机遇,深化赛博–思维新研究,并提升人类对赛博空间的理解与改造能力.

4 赛博学对文明、教育与创新的挑战与机遇

赛博学将在很多领域展现出强大的影响力,这里仅以文明、教育与创新三点为例讨论挑战与机遇.

在文明方面,随着网络空间的发展,文化传播范围虽得以拓展,却也加剧了传播的不可控. 亨利·基辛格等在《人工智能时代与人类价值》[84]中指出:“如果机器智能继续偏离人类思维的范例,那么在我们看来,它将不是人类的映像,而是人类的替代品.”在技术发展的浪潮中,必须坚守人类的核心价值,以确保技术真正服务于人类文明的可持续发展. 在 AI 的加持下,硅基生命的成长及其对碳基生命的挑战,引发人类文明演进路径的深刻思考. 硅基生命在信息处理和环境适应性方面的优势使其具有巨大的发展潜力,如在人工智能领域,基于硅芯片的计算机系统已展现超越人类的计算能力和数据处理能力[85]. 然而,硅基生命的崛起也带来了伦理和可持续性问题. 未来,人类文明的演进可能并非简单的取代或吸收,而是碳基与硅基文明的共融[86]. 与此同时,无论是硅基文明,还是硅基与碳基文明的共融发展,都将极大地影响人类对宇宙的探索和认知.

在教育领域,AI 的迅速发展给教育带来了巨大挑战[87]. 在教学方面,教师借助智能辅导系统和个性化学习平台,从知识传授转向引导学生自主思考. 学习方式也发生转变,学生利用智能学习工具和线上社区,成为知识的创造者与分享者. 学校和教师的角色也发生深刻变化,教师不再是知识的权威,智能教育工具成为学生学习的重要辅助[88]. 同时,专业培养大纲和学制也受到冲击. 传统专业设置难以适应快速变化的知识和技能需求,高校需要不断地更新教学内容和方法,增加跨学科课程,培养具有跨领域视野和创新能力的人才;学制也需灵活调整,以适应终身学习的需求,学习不再是某一阶段的任务,而是贯穿一生的使命,这要求教育体系更加注重学生的自主学习能力培养,以应对未来知识更新和社会需求的不确定性.

在创新方面,AI 的发展正驱动科研范式经历重大变革,继经验、理论、计算及大数据科学之后,一个基于海量数据、超级计算机和深度学习算法的智能科学第五范式正在兴起[84,89]. 从赛博学的视角审视,此变革远超技术迭代,它标志着科研活动向赛博–物理–社会–思维(CPST)空间的全面拓展与深度融合. 在此框架下,AI 不仅是工具,更可能作为“数字人”或人机融合智能体直接参与科研,并作为赛博思维空间(CeT)的核心构成,智能化地加速数据–信息–知识–智能(DIKW)转化链条. 这种范式通过自动化、智能化手段提升数据处理、模式识别与预测能力,并在 CPST 各域(如 CPS (Cyber–physical system) 的模拟优化、CSS (Cyber–social system) 的合作传播、CTS (Cyber–thinking system 的理论发现）中促进了与赛博学理念相符的深度跨学科融合. 面对 AI 在创新中日益核心的地位，基辛格等关于“人类最后一项发明”的警示[84]，直指赛博哲学需深入探讨的核心议题：人工智能崛起对碳基生命主导创新的挑战，以及大模型突破可能预示的人类创新极限或主导权转移. 这些深刻反思关乎人与赛博空间，特别是与高级 AI 的共存互动模式. 因此，赛博学不仅关注技术本身，更致力于为理解这些变革对人类社会、认知、文明演进的全面影响，并为其伦理和未来发展方向提供关键的理论指导.

综上所述，赛博学在文明、教育与创新领域的应用前景广阔，但诸多挑战亟待应对. 未来的发展需要整合技术、政策和社会手段，尤其是开展国际合作与交流，促进文明的交流互鉴，推动教育公平与个性化发展，实现创新与伦理的平衡. 通过跨学科合作，赛博学有望助力构建公平、多样、创新的社会生态，为人类的可持续发展提供支持和指导.

5　结论

本文提出了赛博学，以研究人与网络（赛博）空间关系和基本规律. 首先阐述了赛博学产生的一系列基本问题；然后讨论了赛博学学科体系，以及赛博学给文明、教育与创新带来的挑战与机遇. 最后得出结论，即赛博学对传统的人与自然、人与社会、人与认知问题产生了新的挑战，也将系统变革现有学科体系，对人类文明的发展，以及对宇宙的探索将产生深远的影响.

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