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Cross-Cultural Reconstruction of Shang Aesthetics in *Creation of the Gods I* under the Dual Perspectives of Film and Translation Aesthetics

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Abstract

Taking *Creation of the Gods I: Kingdom of Storms* as the research object, this study examines how Shang Dynasty aesthetics is reconstructed through both cinematic imagery and subtitle translation from the integrated perspective of film aesthetics and translation aesthetics. At the image level, the film draws on archaeological materials and historical documents to visualize the aesthetic characteristics of the Shang Dynasty—such as reverence for white, martial spirit, and ritual propriety—through six dimensions of audiovisual design: military affairs, script, costume, music, ritual vessels, and architecture. These are materialized into visual symbols including military formations, oracle bone inscriptions, costume colors, ritual music systems, bronze decorations, and palatial architecture. At the subtitle level, this study applies Liu Miqing's theory of aesthetic reproduction in translation, Xu Yuanchong's "three beauties" principle, and Wang Yu's dual objectives of "cultural imagery reproduction" and "artistic effect reproduction" to analyze the English translation strategies for key cultural terms such as divinatory terminology, the concept of "heaven's punishment" and father-son ethical maxims. By further integrating multimodal subtitle theory and cross-cultural communication theory, this study discusses the complementary relationship between image and subtitle in the encoding and decoding processes, as well as the risk of "cultural discount". The research argues that through the dual reconstruction of Shang Dynasty aesthetics, *Creation of the Gods I* provides a valuable path for cinematic expression of ancient Chinese civilization and cross-cultural communication, while also exposing tendencies toward simplification and "self-Orientalization".

Keywords
Cross-cultural communication; Film aesthetics; Shang Dynasty aesthetics; Subtitle translation; Translation aesthetics

1. Introduction

From project initiation to the public premiere of the first installment, *Creation of the Gods* took more than a decade. The first film, *Creation of the Gods I: Chaoge in Turmoil* (hereafter "*Creation of the Gods I*"), involved substantial investment in practical set construction, special-effects production, and actor training. Critics have regarded it as an important attempt at becoming a "Chinese mythological epic film" (Wang & Wang, 2023). In a context where an-

cient-costume productions have long been criticized as having a "photo-studio aesthetic" and a "weak evidentiary/historical basis," the film demonstrates a relatively high overall standard in costume, props, and scene design, making its systematic visual depiction of Shang Dynasty civilization especially worthy of attention.

Existing studies on *Creation of the Gods I* mainly focus on its epic narrative and genre innovation. Zhang argues that the film constructs two core motifs—"power succession" and "the positioning of human value"—through a dual symbolic system of both history and myth (Zhang, 2023). Wang and Wang summarize the film's innovations in narrative reconstruction, industrial aesthetics, and the reactivation of cultural symbols (Wang & Wang, 2023). However, these studies largely remain at the levels of narrative and genre, leaving relatively underexplored questions such as: "How are Shang aesthetic elements overall configured in the film?" and "How do subtitles participate in reconstruction in cross-linguistic communication?"

Against this backdrop, this paper focuses on a dual reconstruction mechanism of Shang Dynasty aesthetics in *Creation of the Gods I*: first, how the film, within the framework of film aesthetics, achieves an overall construction of Shang aesthetics through visual elements such as "military, writing, clothing, music, ritual, and architecture"; second, how this Shang aesthetic is cross-linguistically reproduced in the conversion of Chinese and English subtitles—what kinds of interactions emerge between image and subtitle, and what roles and risks this has for cross-cultural communication. By building on an integrated examination of visual styling and subtitle translation, and from the intersection of film aesthetics, translation aesthetics, and cross-cultural communication, this paper explores the pathways and tensions of the contemporary reconstruction of Shang aesthetics.

2. Theoretical Framework and Research Perspectives

2.1 Ancient Costume Film and Cultural Symbols from the Perspective of Film Aesthetics

As a comprehensive art form, film's aesthetic construction depends on modern industrial technologies and narrative models, while also being deeply rooted in the cultural soil of specific nations. Shi notes that "the task of film aesthetics research is to observe film with an aesthetic spirit" (Shi, 2016). He further divides film aesthetics into two dimensions: ontology and functionalism. The former focuses on general artistic rules of film, while the latter emphasizes differences in aesthetic functions of film across different nations and historical contexts. Building on this, Huang et al. (1999) further argue that Chinese cinema, while absorbing global film experience, should in narrative and design clearly display distinctive Chinese cultural characteristics. This theoretical stance provides the basic perspective for examining how *Creation of the Gods I* reconstructs Shang aesthetics within a modern film-industry framework.

As an intersection of historical imagination and contemporary aesthetic experience, ancient-costume film aesthetics involve not only surface symbols such as clothing and props, but also how audiovisual language presents the spiritual temperament and value order of a specific historical period. Li (2022) argues that traditional cultural symbols in character costumes, architectural layouts, and ritual institutions are core carriers that enable ancient-costume themes to achieve "aesthetic imaging". However, the meanings of these symbols are not fixed. From the perspective of theatrical and film art design, Song (2020) divides national cultural symbols into three levels: content, form, and materials, stressing that their significance is recoded in specific contexts. That is to say, when the Shang taotie motif is transferred from bronze ritual vessels to armor, palace walls, and costumes in film, its symbolic function expands: it not only

points to the ancient religious-political structure, but also serves to shape the overall "austere, mysterious, and oppressive" atmosphere of the Shang world.

This understanding is essential for grasping the aesthetic strategy of *Creation of the Gods I*. The film does not simply "restore" Shang elements found in archaeological catalogs; rather, through systematic integration of oracle bone inscriptions, bronze ritual objects, ancestral temple architecture, and battle-array compositions, it transforms Shang cultural symbols scattered across historical texts into a unified audio-visual style. This integration is simultaneously aesthetic construction and cultural interpretation: it requires creators to select and intensify the core features of Shang aesthetics under the premise of respecting historical materials.

2.2 Historical Foundations and Symbolic Resources of Shang Aesthetics

To understand the reconstruction of Shang aesthetics in *Creation of the Gods I*, it is first necessary to clarify what Shang aesthetics generally looked like in its historical context. In the Shang period, oracle bone inscriptions, bronze ritual objects, ancestral temple architecture, and sacrificial rites and music formed a relatively complete aesthetic world. Oracle bone divinations were not merely records of writing; they were also material carriers of the Shang people's religious psychology of "divining everything." Zhu (2014) research on the calligraphic aesthetics of oracle bone inscriptions shows that large characters were "bold, sturdy, round and turning," while small characters were "fine, strong, and upright," and that the layout and composition reflect a rustic yet orderly beauty of writing. This aesthetic quality concerns not only form, but is also closely related to the Shang people's reverence for the "Mandate of Heaven" and their pursuit of order.

Bronze ritual objects are the most representative material form of Shang aesthetics. The taotie, kui-long patterns, and other motifs on bronze wares—through exaggerated eyes, complex lines, and strict symmetrical structures—create a visual impression of "terrifying-sublime," which serves as a concentrated symbol of power, taboo, and religious awe (Li, 2009). The dual nature of "terrifying-sublime" arises both from the visual impact of the patterns themselves and from the sacrificial functions and hierarchical order they carried. In other words, the taotie motif is not merely decoration; it is a visual metaphor for the Shang political-religious structure.

In terms of color perception, "the Shang people favored white" is an important dimension of Shang aesthetics. Li (1991), through documentary research, argues that the Shang people generally esteemed white, linking it closely to sacrifices, arms and armor, and ritual practices. Du (2001) further contends that this color preference was not accidental but related to the Shang cosmology and political ideas. In *Creation of the Gods I*, large numbers of white-armored military formations and white ceremonial clothing provide a modern visual transposition of this concept, turning "favoring white" from textual records into a perceptible audiovisual symbol.

2.3 Translation Aesthetics and Cross-cultural Reproduction through Multimodal Subtitles

Cross-cultural dissemination of film works relies not only on the images themselves, but also on subtitles that cross-linguistically translate cultural meaning. From the perspective of translation aesthetics, Liu (1986) proposed the requirement of "aesthetic representation," emphasizing that translators should reconstruct the original's aesthetic features on the basis of semantic fidelity. Xu Yuanchong, by contrast, specified this requirement through the "three beauties" principle—meaning beauty, sound beauty, and form beauty—arguing that the translation should be as close as possible to the original in meaning, rhyme/sound, and form.

However, film subtitles differ from literary translation: they must deliver meaning within extremely limited time and with a very restricted number of words, and they are always constrained by other modalities such as images, performances, and music.

Wang Yu, in his research on film translation, proposes two major goals: "cultural imagery reproduction" and "artistic effect reproduction." He argues that subtitles must seek a balance between preserving culturally loaded information and creating an overall artistic effect (Wang, 2020). This theoretical framework is important for analyzing the subtitle strategies in *Creation of the Gods I*. The film contains numerous Shang culture–loaded terms such as the divination expression "wuwang (no delusion)," the religious concept "tianqian (Heaven's punishment)," and ethical aphorisms about kinship and subjectivity. These words contain rich historical and philosophical connotations in Chinese contexts, yet in cross-linguistic conversion they often face the dilemma of being "untranslatable" or "difficult to translate fully." Subtitle translators must weigh "complete transmission of cultural imagery" against "ensuring audience understanding of plot and emotion."

The multimodal perspective further reminds us that subtitles are only one part of meaning construction in film texts. Film texts can be categorized into four core modalities: visual non-verbal, visual verbal, auditory verbal, and auditory non-verbal (Yang, 2023). In *Creation of the Gods I*, taotie patterns, bronze color tones, elevated palace structures, and battle drum rhythms have already conveyed substantial Shang aesthetic information at the audiovisual level. Therefore, subtitles may in some instances appropriately simplify cultural explanations, leaving more work to the image modality; but for highly abstract concepts such as "wuwang" and "tianqian," which lack direct and intuitive visual correspondences, subtitles must assume a greater burden of semantic interpretation. This multimodal complementary mechanism is both a basic law of film translation and the key to understanding the cross-cultural communication strategy of *Creation of the Gods I*.

2.4 "Cultural Discount" and Symbol Encoding in Cross-cultural Communication

In the context of globalization, the core challenge for Chinese film going global lies in how to maintain cultural distinctiveness while reducing "cultural discount." Film production is an "encoding" process, while the audience's watching is a "decoding" process; in-between, there inevitably exist comprehension deviations caused by differences in cultural background (Li & Li, 2021). Chinese culture tends to be high-context: information transfer relies on background knowledge and implicit expression. The English-speaking world tends to be low-context, emphasizing explicit information and direct expression (Zhang & Qi, 2022). This suggests that for Chinese films to gain broader understanding in international markets, they need to strike a balance between "maintaining cultural difference" and "adopting globally intelligible narrative modes."

Yet such a balance is also fraught with risk. Some works, in order to cater to "the West's imagination of China," overemphasize surface visual spectacles, treating national cultural symbols as decorations of exotic flavor while neglecting their underlying spiritual connotations and value systems—thus resulting in what is called "self-othering" (Li & Li, 2021). In the visual construction of Shang aesthetics and the subtitle transposition in *Creation of the Gods I*, precisely this tension is at stake: the film must present the unique temperament of Shang civilization through visual symbols such as white-armored armies, taotie patterns, and elevated palaces so that audiences from different cultural backgrounds can understand them through subtitles; it must preserve cultural depth while avoiding the trap of turning into a self-exhibi-

tion of "Oriental exoticism."

3. Image Layer: Visual Reconstruction of Shang Aesthetic Elements

Creation of the Gods I's reconstruction of Shang aesthetics is first reflected in the overall unity of its audio-visual style. Zhang (2023: 75)points out that the epic "sense of authenticity" comes from solid scripting, art research, and meticulous coordination of costumes, props, and set design. Through a systematic integration of color tones, camera language, and sound design, the film constructs a "Shang atmosphere" that differs from earlier ancient-costume films. In terms of color, Chaoge is dominated by cool tones: high walls, bronze columns, and the dim De Hall together create an oppressive atmosphere. By contrast, Xiqi is rendered in warm tones through golden wheat fields and homespun clothing, forming a visual contrast between tyranny and benevolence, oppression and growth (Wang & Wang, 2023). The camera language uses a large number of wide shots, overhead angles, and long takes to present battlefield and ceremonial scenes, making the grand scale of the Shang world and its power hierarchy intuitively visible. In terms of sound, battle drums and horns interact with bronze bells and chime instruments in military and ritual spaces, reinforcing the audience's emotional experience of Shang martial spirit and religious awe.

3.1 "Military": Military Formations as Ritual Display and Martial Spirit

The Shang regime had a strong military character; oracle bone inscriptions record numerous accounts of campaigns and hunts, reflecting a martial spirit (Shi, 2006). The film's reconstruction of the "military" dimension is mainly embodied in its army formation systems, pre-battle rituals, and weapon/armor design.

In the snow battle in Jizhou, the princely armies in white armor form neat square formations. White armor blends into the snow, echoing the "Shang people favored white" notion while producing a cold tactical effect (Li, 1991: 75). Overhead shots and wide shots highlight the aesthetic beauty of the array and the collective might, turning the army formation itself into a ritual-like visual spectacle. The brief solemn standing before battle and the silent gazes at the fallen after battle dilute any romanticization of war, emphasizing sacrifice and responsibility. The film deliberately underscores the princely youths' "flesh-and-blood mortal identity," preserving the weight of individual lives even within the grand formation (Zhang, 2023: 75). Weapon and armor designs reference Shang bronze armor patterns; beast-face motifs and sharply angled features on chest and shoulder pieces reinforce the army's cold image. The army formation system and pre-battle rituals jointly transform Shang martial spirit from an abstract idea into a visible and ritualized aesthetic scene.

3.2 "Writing": Oracle Bone Inscriptions and Theocratic Political Power

Oracle bone inscriptions are the most important cultural heritage of the Shang civilization. The Shang people wrote on oracle bones (jia: tortoise shells; gu: animal bones, mainly ox bones) either on top of writing or with cinnabar marks, along with ink inscriptions; some were written first and then carved, while others were carved directly without prior writing. Some characters were painted with cinnabar or ink; others even had turquoise inlaid—these constitute so-called divination inscriptions (Lei, 2019).

Through divination chambers and text reliefs inside and outside the De Hall, the film tightly binds the visual order of oracle bone inscriptions with the theocratic politics of power. Zhu's (2014: 83) study of the calligraphic aesthetics of oracle bone inscriptions shows that their

compositional layout expresses a "simple yet orderly" beauty of writing. This sense of order resonates with the stateliness of the Shang theocratic system: the standardization of writing itself is the visual manifestation of the idea that "the Mandate cannot be violated," and only those who master writing have the authority to communicate with divine will. The film translates this mechanism into concrete images. Diviners carve and burn characters on tortoise shells; close-ups of crack expansion are paired with low, heavy music, creating an atmosphere of mystery and tension. Rows of standing tortoise shells and divination-related ritual objects form a space connecting humans and gods.

Shi Changyou's research on oracle bones from Yinxu confirms that the writing and reading power of Shang oracle bone inscriptions was controlled by the royal family, becoming a political tool to monopolize divine oracles and strengthen royal power (Shi, 2006: 134). This power mechanism is fully demonstrated in the plot where Yinshou (King Zhou) distorts the divination. When "wuwang (no delusion) brings calamity" is twisted into accusations against the princes, the camera emphasizes the contrast between written text and human expressions: the oracle bone inscription is ambiguous, but the interpretive right is monopolized by the king.

Zhang Yuan points out that in the late Shang, patriarchy, monarchy, and theocratic power interwove, and oracle bone inscriptions were the key pivot of this structure—Yinshou, as both "monarch and father," controls the right to interpret writings, and as "spokesperson of the gods," announces heavenly punishment, thereby combining these three powers into one (Zhang, 2023: 76). Oracle bone inscriptions and divination rituals thus cease to be mere religious symbols and instead become visual metaphors for Yinshou's consolidation of tyranny.

3.3 "Clothing": Costume Color and Hierarchical Order

Shang clothing exhibited a distinct "white-favoring" tendency in both color selection and the application of patterns, and it strictly reflected hierarchical differences (Du, 2001). The film's overall costume design follows a color system of "white as the main tone, black and gold as secondary," combining the solemn style of Shang clothing with character psychology shaping.

Military uniforms heavily adopt white armor, both echoing the "favoring white" notion and playing a camouflage role in the snow battle in Jizhou. White-armored ranks become visual symbols of "coldness, neatness, and brutality." Royal and noble attire is more complex in color and patterns: Yinshou's regular and ceremonial clothes often use deep-colored fabrics paired with bronze patterns. In the coronation ceremony robes, taotie motifs on shoulders and chest echo the De Hall's columns, reinforcing his connection to bronze civilization and ancestral sacrifices. The clothing of the Zhou people is clearly distinct from the Shang in color and materials: Ji Chang and Ji Fa often wear earthy yellow and bluish-grey homespun garments, which harmonize with Xiqi's wheat-field environment, implying their proximity to agrarian life and "popular support." The contrast between Chaoge and Xiqi costumes transforms abstract oppositions—"tyranny/benevolence" and "theocratic power/people-oriented governance"—into visible differences easily recognized by audiences (Wang & Wang, 2023: 147).

3.4 "Music": Ritual Music, Dance, and the Reconstruction of Ceremony

Although Shang ritual music was not as systematically developed as in the Zhou period, archaeology and textual evidence show that it already had relatively rich musical instruments and traditions of ritual dance (Shi, 2006: 154). According to oracle bone divination texts, music and dance had already become important subjects for learning among the nobility's children in the Shang dynasty (Wu, 2015: 124). Through scenes such as the sacrificial dance in

Jizhou, the princely battle dance, and the grand De Hall ceremony in Chaoge, the film reconstructs the spirit of Shang ritual music.

In the Jizhou sacrifice, drum stones and group chanting create a solemn and sorrowful atmosphere. The subsequent princely battle dance, accompanied by percussion and metallic sounds, forms a "martial entry into ritual" music-and-dance style: synchronized stomping and arm movements holding spears and performing gestures construct a choreography that is at once sacrificial and military drill. Fast-paced editing and low-angle tracking emphasize changes in formations and bodily strength, making the battle dance serve a dual function of ceremony and military training (Li, 2022: 88). In the De Hall ceremony, bronze chimes and bianzhong instruments produce a steady and deep sound. The music-and-dance rhythm is slow and solemn; paired with elevated palace architecture and the Xuanbird (mystical bird) totem, it builds a sacred yet oppressive power atmosphere. In Xiqi scenes, wooden instruments and string music are used more often, with gentle melodies and bright timbres that create an ambience of peace.

3.5 "Ritual": Bronze Ritual Vessels and the Majesty of Power

Bronze ritual vessels and taotie patterns are concentrated expressions of Shang material culture and aesthetic tradition. In Shang bronze art, the visual experience of patterns is emphasized; ruling groups always care about images that have strong visual impact (Wang, 2019). In the "ritual" dimension, the film systematically deploys these elements so that taotie patterns extend from ritual vessels to architecture, clothing, and weapon surfaces, forming a visual motif throughout.

In the De Hall scenes, firelight illuminates the depth and relief of three-dimensional textures; close-ups intensify the "terrifying-sublime" primitive aesthetics, implying religious majesty and power intimidation. The film keeps the taotie motif's core features across different carriers—symmetrical structures and giant eyes and ferocious teeth—thus continuing the traditional "awe and admonition" meanings while also turning it into a visual mark of the Shang regime's cold image. The placement of ritual vessels also conveys order: in the grand ceremony, ding and gui vessels are arranged symmetrically by rank; the royal seat is elevated above the others; the vassals and officials are placed in ordered tiers—space positions directly concretize power hierarchy.

3.6 "Architecture": Palace Buildings and Spatial Power

The spatial organization of Shang architecture itself carries political implication. Through its reconstruction of the De Hall in Chaoge, the film builds a power space: elevated platforms, long staircases, and a symmetrical central-axis layout form a vertical system so that physical height directly corresponds to power rank. The camera often shoots from low angles at the base of platforms, intensifying the sense of oppression from below the power hierarchy. Characters' actions of ascending/descending the hall are ritualized, implying that power ranks are impossible to transgress. Architecture space thus becomes a translator of political order: Chaoge's city walls are closed and towering, with narrow streets and alleys creating a suffocating atmosphere; Xiqi is depicted with open plains and low, un-walled dwellings. This sharp contrast allows the ideological differences between "vertical authoritarian space" and "horizontal livelihood space" to be visually articulated (Wang & Wang, 2023: 148), laying groundwork for the later analysis of value conflicts in the Shang-feng universe.

Taken together across six dimensions—"military, writing, clothing, music, ritual, and archi-

tecture"—it is evident that the film constructs an aesthetic field of Shang culture through systematic integration of symbols. This visual encoding not only restores the ancient meaning of Shang civilization from an archaeological perspective, but also creates an imagery system that can be perceived by audiences from different cultural backgrounds, providing an important cognitive basis for cross-linguistic reconstruction in the subtitle layer.

4. Subtitle Layer: Cross-linguistic Reconstruction of Shang Cultural Concepts

Each human language depicts the world in different ways, and each language constructs a set of possible worlds (Steiner, 2020). Language is one way of constructing aesthetic worlds, and translation is a process of reconstructing or representing those aesthetic worlds. Many concepts in Shang aesthetics—such as the divination term "wuwang (no delusion)," the religious concept "tianqian (Heaven's punishment)," and ethical aphorisms about kinship and subjectivity—are highly localized culture-loaded terms. Subtitle translation must, while transmitting key information, also take aesthetic effects into account. Liu and Xu's (2006) translation aesthetics stress that the translation should reconstruct the original's aesthetic world in terms of meaning and form. Wang (2020: 30) proposes that film translation aims at both "cultural imagery reproduction" and "artistic effect reproduction"

Multimodal subtitle theory indicates that subtitles are only one part of the film text; many cultural meanings can be conveyed through images and music (Yang, 2023). In *Creation of the Gods I*, taotie patterns, elevated palace halls, and white-armored army arrays have already presented the Shang atmosphere through visual means, so subtitles may appropriately "step back"; however, for abstract concepts such as "wuwang" and "tianqian," if adequate transference is not made, audiences may struggle to understand narrative logic. Therefore, subtitles must deliver aestheticized interpretations within limited word counts.

4.1 "Guā (hexagram)" and "Wuwang": An Adapted Translation Strategy for Terminology

In oracle bone inscriptions, "wuwang" functions both as the hexagram name of the Book of Changes and also carries meaning akin to "not indulging in delusions" or "not being deserving of disaster" (Shi, 2006: 85). In the film, when the diviner reports "wuwang brings calamity," a direct translation such as "Wu Wang" or "Non-delusion" would likely puzzle viewers. In practice, the subtitles mostly adopt paraphrasing/meaning translation such as "unexpected calamity" or "disaster without cause," weakening the technicality of the hexagram name while foregrounding the semantic core of "unexpected calamity."

This treatment sacrifices the cultural imagery of the hexagram name, yet it ensures the key information necessary for narrative progression. As Wang Yu describes, "cultural imagery reproduction" is compressed here, while "artistic effect reproduction" is prioritized (Wang, 2020: 30). Nevertheless, in the scene of divination, the burning of the tortoise shell, the spread of cracks, and the dim environment of the divination chamber create an atmosphere of "divine will that is hard to fathom" through images; multimodal coordination largely compensates, to some extent, for the cultural loss caused by simplified terminology (Yang, 2023: 65).

4.2 "Heaven's Punishment": Assimilation and Handling of Religious Concepts

In Chinese contexts, "tianqian" implies a tripartite order of heaven–person–ruler, referring to "heaven's punishment of the unjust." Behind it lies the Shang-specific philosophy of "the resonance between heaven and humanity": Heaven's will is manifested through the ruler's virtue; when virtue is lost, Heaven sends disaster and omens accordingly. In subtitles, "tianqian"

is rendered as "heaven's punishment," "divine retribution," or "Apocalypse." The first two expressions are more linguistically close to the original, preserving the subject of divine punishment. "Apocalypse," however, comes from Western religious tradition and carries strong apocalyptic connotations.

This assimilation choice faces a classic dilemma in translation studies. In terms of artistic effect, "Apocalypse" is more likely to activate English audiences' apocalyptic imagination resources, intensifying emotional impact. But in terms of cultural imagery, it blurs the philosophical connotations of "tianqian"—Shang "Heaven's punishment" emphasizes moral causality (loss of virtue → disaster and omens), while Western "Apocalypse" tends to focus on an ultimate judgment that is beyond human control. Film subtitles often have to choose between "cultural imagery reproduction" and "artistic effect reproduction" (Wang, 2020). Clearly, the selection of "Apocalypse" prioritizes the latter: replacing an unfamiliar Confucian-style Mandate of Heaven worldview with religious symbols familiar to English audiences yields more immediate emotional resonance.

Yet this assimilation-driven cultural simplification is partly offset by the film's narrative imagery. The film presents the moral premise of "Heaven's punishment" through a progressive depiction of Yinshou's tyranny, the breakdown of ritual music and ceremonial order, and the accumulation of public grievances. It makes clear that punishment is not a disaster without cause; rather, it is the inevitable outcome of a tyrant who has lost virtue. The image modality injects ethical dimensions into "Apocalypse," partially offsetting the stereotype of "irrational catastrophe." However, the fine distinctions in the Shang philosophy of the resonance between heaven and humanity (for example, the causal chain of virtue → resonance → disaster and omens) remain difficult to convey fully in subtitles. This is precisely the inevitable "loss" when high-context cultural information is cross-linguistically converted (Zhang & Qi, 2022).

4.3 Father-Son Aphorisms: Formal Reproduction of Ethical Propositions

In the film, the aphorism "It doesn't matter whose son you are; what matters is who you are" concentrates the conflict between father-son ethics and self-identity. Zhang Yuan argues that the film's epic themes crystallize into two motifs: "power succession" and "the positioning of human value." Ji Fa's choice embodies the turn from lineage identity to subjectivity awareness (Zhang, 2023).

A common English rendering is: "Whose son you are doesn't matter. Who you are does." This translation basically reproduces the original's logic and rhythm in both meaning and form, using the parallelism of "does/doesn't/matter" to achieve a certain rhetorical beauty. According to Xu Yuanchong's "three beauties" principle, this translation performs well in both meaning beauty and form beauty.

But within cultural context, "whose son you are" is not only about family; it is tightly connected to the patriarchal clan structure and the structural analogy between family and state. "Who you are" also links to moral choice and the question of "what one should be loyal to." In English contexts, "Who you are" tends to point more toward modern individualism and self-realization. Wei (2025) notes that the success of the Nezha series lies in transforming Chinese relational ethics of family into a globally comprehensible narrative of individual growth. The English subtitle rendering of this aphorism undergoes a similar process: it retains parts of the father-son relational structure, yet transfers the deeper family-state ethical meanings into a theme of "personal growth." This transference benefits cross-cultural understanding, but it inevitably simplifies the complex meanings embedded in Shang ritual-system contexts.

Overall, in subtitle translation of Shang culture–loaded terms, *Creation of the Gods I* generally adopts a strategy of "moderate domestication plus multimodal coordination." For terms such as "wuwang," subtitles prioritize conveying the "calamity" information. For "tianqian," subtitles oscillate between religious punishment and apocalyptic imagery. For father-son aphorisms, subtitles balance formal rhythm with universal emotional resonance. From the perspective of translation aesthetics, these choices align with the basic requirement of "pursuing aesthetic representation under technical constraints" (Liu, 1986: 23; Wang, 2020: 30). The multimodal perspective also shows that subtitles are not a "panoramic window" into Shang aesthetics; rather, they function as a "selective window" that works together with images and music (Yang, 2023: 66). Much of Shang aesthetics is actually carried by costume and props and by staging/scene composition, while subtitles only provide language labels at crucial moments. Still, the problem of "cultural discount" persists: some Shang thought resources may be absorbed into globally mainstream narrative frameworks and interpreted as general disaster films or coming-of-age film language.

5. Interaction between Image and Subtitles: Pathways and Risks for Cross-cultural Communication

5.1 Multimodal Complementarity and "Cultural Discount" as Buffer

For overseas audiences, the Shang world in *Creation of the Gods I* must be decoded through the combined efforts of images and subtitles. Images create sensorial impressions and symbol structures, while subtitles provide minimal linguistic guidance. Yang's (2023) theory of multimodal integration of key modalities indicates that modalities complement each other rather than replace one another. In the film, formations such as the white-armored army, taotie patterns, and elevated palace halls have already strongly presented Shang aesthetics visually; therefore, subtitles do not need to carry all the cultural explanation. Instead, they can focus on narrative clarity and emotional guidance.

From a semiotic perspective, this kind of multimodal complementarity can, to a certain extent, buffer "cultural discount." In film production and reception, encoding/decoing are interactive processes. Meaning deviations caused by cultural background differences are inevitable (Li & Li, 2021: 5). In the encoding stage, *Creation of the Gods I* builds a narrative through differentiated Shang symbols and universal emotional motifs (power succession, father-son conflict, and individual awakening). In the decoding stage, subtitles lower comprehension barriers through domestication and simplification. Together, they enable Shang aesthetics to preserve a certain "heterogeneous feel" while not becoming completely incomprehensible.

5.2 Cross-cultural Storytelling Pathways for a Chinese Tale

Telling Chinese stories well has become an important mission for Chinese films to go global. Zhang Qi points out that Chinese culture tends to be high-context: communication relies on background knowledge and implicit expression; the English-speaking world tends to be low-context and favors explicit information (Zhang, 2023). In cross-cultural communication, Chinese cinema needs to transform the high-context cultural core into images and narratives that can be perceived in a low-context way. It must preserve cultural specificity while achieving cross-cultural understanding through universal emotional and narrative structures.

Creation of the Gods I exactly realizes this through "local aesthetics + mainstream narrative." On one hand, Shang symbols such as white-favoring costumes, bronze ritual objects, oracle

bone divination inscriptions, and elevated palace structures form a distinctive Shang symbol group, ensuring the unique character of Shang aesthetics. On the other hand, in narrative structure, the film approaches a "three-act" pattern. In character portrayal, it strengthens Ji Fa's growth arc and the father-son conflict, thus engaging in dialogue with globally mainstream heroic narratives (Wang & Wang, 2023). Subtitles render fate, Heaven's punishment, and the importance of subjectivity choice—through expressions such as "fate," "heaven's punishment," and "Who you are matters"—turning parts of Shang contexts into values language acceptable for global audiences (Wei, 2025: 43).

This strategy's positive significance lies in the fact that Shang aesthetics is no longer merely a conceptual category from textbooks. It becomes a visible, perceivable, and communicable cultural resource. At the same time, it also means a certain degree of "decomplexification." Zhang Yuan highlights that the precise Shang destiny worldview consists of a "triadic structure" of patriarchy, monarchy, and theocracy; yet within subtitles and a general global narrative framework, this fine structure is simplified into a more common pattern of "tyrant—hero—father-son conflict" (Zhang, 2023: 74).

5.3 Risks and Reflection: "Oriental Spectacle" and Self-othering

In global markets, exporting Shang aesthetics also faces the risk of becoming "Oriental spectacle." Li Ran and Wang Jia Yi have warned that some works overemphasize surface visual effects, reduce national cultural symbols into decorative exotic flavor elements, ignore the underlying thought and historical logic, and ultimately fall into the predicament of "self-othering" (Li & Wang, 2021). Wu's (2020) research further suggests that in ancient-costume dramas, the arbitrary patchwork of folk customs and clothing often dissolves the deeper structure of national culture, turning it into visual symbols that can be consumed casually.

Creation of the Gods I is relatively rigorous in image construction. Taotie patterns, bronze ritual objects, and elevated palaces are not isolated visual elements; they are closely linked to characters' destinies and power struggles. The oppression of the De Hall space in Yinshou's fall, the breakdown of ritual order when Ji Fa awakens, and the cold-savage presence of bronze instruments in the sacrifice of the princes—these symbols consistently serve a philosophical narrative about desire, power, and subject value. To a certain extent, this helps avoid a simplistic "spectacle pile-up." However, when the film moves toward the global market, the dissemination discourse framework becomes equally crucial. If marketing strategies overly emphasize "Oriental magic" and "guofeng visuals," while diluting the ideological connotations and historical thickness of Shang culture, the film may still fall into the trap of self-watching through "the eyes of the Western other."

Risks also exist at the subtitle level. When "Heaven's punishment" is categorized into a "Apocalypse"-style apocalyptic narrative framework, and when divination rituals are simplified into ordinary "fortune-telling," Shang's distinctive "resonance between heaven and humanity" worldview and ritual logic may be assimilated into foreign cultural interpretive frames. The academic value of this study lies precisely here: by systematically analyzing cultural connotations inside image symbols and subtitle strategies, the study can reveal the possible tendency toward spectacle. This provides theoretical references for creators in seeking a balance between market communication and cultural expression.

6. Conclusion

As an important practice of contemporary Chinese ancient-costume fantasy cinema in recent

years, *Creation of the Gods I* provides rich material for observing the contemporary reconstruction of Shang aesthetics and its cross-cultural dissemination.

From a dual reconstruction perspective—moving from image to subtitles—this study explores how Shang aesthetics is presented on screen and how it operates in cross-cultural communication. At the image level, the film integrates Shang elements across six dimensions—"military, writing, clothing, music, ritual, and architecture"—turning white-armored army formations, oracle bone divination inscriptions, taotie decorative motifs, elevated palace structures, and ritual dances into a cold, solemn, and mysterious visual field. This construction is grounded in archaeology and historical documents, while also endowing symbols with narrative functions through character portrayal and staging. Oracle bone inscriptions are no longer static cultural heritage but become instruments of theocratic political control. Taotie decorative motifs are no longer merely decorative motifs, but visual marks of the Shang regime's authority and terror. The vertical space of elevated palace structures becomes a direct translation of power hierarchy. Through such narrative-ization of symbols, Shang aesthetics moves beyond the level of "cultural exhibition," turning into an audiovisual system that advances plot and themes.

At the subtitle level, English subtitles negotiate the balance between "cultural imagery reproduction" and "artistic effect reproduction" when dealing with divination terminology, religious concepts, and father-son ethical aphorisms. Through paraphrasing, domestication, and rhythmization, subtitles guarantee narrative comprehension and emotional resonance while inevitably simplifying parts of Shang ideological resources: "Heaven's punishment" is reframed within a Western "Apocalypse" framework; "divination" is simplified into the commonplace "fortune-telling"; and the Confucian ethical connotations embedded in father-son aphorisms are transformed into universal moral admonitions. Multimodal analysis shows that subtitles function more like a "selective window" in the cross-linguistic reconstruction of Shang aesthetics: the image layer preserves cultural difference through its visual symbol system, while the subtitle layer lowers comprehension thresholds through domestication strategies. Together, they form a compound mechanism of Shang aesthetics for overseas communication.

This mechanism demonstrates a feasible pathway for cinematic inscription of ancient Chinese civilization. On one hand, through systematic symbol reconstruction, cultural specificity is maintained, ensuring that Shang differs from the generalized "ancient China" commonly found in commercial blockbusters. On the other hand, by embedding cultural symbols into internationally recognizable heroic coming-of-age and ethical-choice narrative frameworks, differences become perceptible and shareable through universality. Yet this pathway also exposes risks: if subtitle domestication over-simplifies ideological connotations, and if marketing overemphasizes "Oriental magic" visuals, Shang aesthetics may still drift toward "Oriental spectacle" and "self-othering." Future research can, based on this, further compare how different phases of the trilogy reconstruct aesthetics, incorporate audience empirical investigations, and conduct version comparisons of subtitles in order to examine more precisely the decoding pathways of Shang aesthetics under different cultural contexts. Research can also place *Creation of the Gods I* alongside works such as The Assassin/ Demon Cat and Chang'an 30,000 Miles in a comparative framework, exploring aesthetic strategies and translation strategies of cinematic inscription of ancient Chinese civilization across different times and spaces—thereby providing more empirical materials for building a cross-cultural communication theory of Chinese cinema with stronger subjectivity and depth.

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References

Ba, X. (2025). An Analysis of the Path of Cross-Cultural Communication of Chinese Films. *Media Era*, 9, 42-44.

Du, D. (2001). A Textual Research on 'The Yin People Esteemed White'. *A Collection of Oriental Essays*, 4, 13.

Hu, H. (1993). Preface to Introduction to Oracle Bone Inscriptions from Yinxu. *Chinese Character Culture*, 3, 4-6.

Huang, H., Zhou, X., Zhang, T., Yu D. (1999). A Discussion on 'Research on Chinese Film and Television Aesthetics'. *Social Sciences in China*, 3, 184-196.

Lei, H. (2019). *Outline of National History*. Nanjing: Jiangsu People's Publishing House.

Li, B. (1991). From the Yin People Esteeming White to Confucius's Simplicity-Based Philosophy. *Qilu Journal*, 6, 71-76.

Li, R., & Li, J. (2021). Cross-Cultural Communication of Chinese Film and Television Works from the Perspective of Semiotics. *Movie Review*, 16, 1-5.

Li, X. (2022). Aesthetic Imaging of Costume Film and Television Creation Nourished by National Culture. *Movie Review*, 8, 86-88.

Li, Z. (2009). The Path of Beauty. Beijing: SDX Joint Publishing Company.

Liu, M. (1986). Basic Theoretical Conceptions of Translation Aesthetics. *Chinese Translators Journal*, 4, 19-24.

Liu, M. (2012). Introduction to Translation Aesthetics (2nd ed.). Beijing: China Translation & Publishing Corporation.

Shi, C. (2006). Splendid Yin-Shang Culture. Beijing: China Social Sciences Press.

Shi, K. (2016). A Course in Film and Television Aesthetics. Beijing: Beijing Normal University Publishing.

Song, D. (2021). Discussion on the Application of National Cultural Symbols in Art Design of Drama, Film and Television. *Chinese Handicraft*, 3, 58-59.

Steiner, G. (2020). After Babel: Aspects of Language and Translation (X. Meng, Trans.). Hangzhou: Zhejiang University Press.

Wang, Y. (2019). A Study on the Aesthetics of Ritual and Music in the Western Zhou Dynasty. Beijing: China Social Sciences Press.

Wang, Y. (2025). Research on the Cultural and Artistic Representation of Film and Television Translation. *Comparative Study of Cultural Innovation*, 15, 28-31.

Wang, Y., & Wang, Z. (2023). Creation of the Gods I: Kingdom of Storms: Innovative Expression of Domestic Mythological Epic Films. *Movie Literature*, 23, 147-150.

Wu, C. (2015). Draft History of Yin-Shang Cultural Communication. Guangzhou: Jinan University Press.

Wu, L. (2020). On National Culture and Film Aesthetics in Costume Film and Television Works. *Western Radio and Television*, 4, 139-141.

Xu, Y. (2006). The Art of Translation (Rev. ed.). Beijing: China Intercontinental Press.

Yang, S., & Xue, Q. (2023). Research on Subtitle Translation from the Perspective of Core Modal Integration. *Computer-Assisted Foreign Language Education*, 3, 58-66.

Zhang, G. (2004). The Bronze Age of China. Beijing: SDX Joint Publishing Company.

Zhang, Q., & Qi, W. (2022). Analysis on Image Encoding and Decoding of Chinese Stories in the Context of Cross-Cultural Communication. *Movie Review*, 4, 47-52.

Zhang, Y. (2025). Inquiry into the Presentation, Connotation and Significance of Epic Films—Taking Creation of the Gods I: Kingdom of Storms as an Example. *Journal of Wuyi University*, 2, 71-76.

Zhu, Y. (2014). Culture and Concepts of Shang Dynasty Society. Tianjin: Nankai University Press.

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From Digital Twin to Digital Cognition: A Multilevel Model of Algorithmic Intelligence in Smart Manufacturing Systems

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Abstract

This study extends the dominant digital twin paradigm by introducing the concept of digital cognition to explain the evolving nature of smart manufacturing systems. While prior research largely conceptualizes digital twins as passive representations for monitoring and simulation, we argue that advanced manufacturing systems increasingly exhibit algorithmic intelligence through the integration of predictive models, real-time control, and adaptive feedback mechanisms. Drawing on an in-depth case study of a fully automated precision grinding system, this paper develops a multilevel model that explains how algorithmic intelligence emerges from the interaction of three interdependent layers: (1) a perceptual infrastructure enabled by high-resolution sensor networks and real-time data acquisition; (2) an algorithmic reasoning layer driven by machine learning models such as LSTM-based prediction and thermal deformation compensation algorithms; and (3) an autonomous actuation layer realized through high-speed synchronized control architectures. The findings show that the emergence of digital cognition transforms manufacturing systems from reactive optimization tools into proactive and self-adaptive agents, significantly enhancing precision, efficiency, and operational reliability. This transformation also reconfigures control structures by shifting decision-making authority from human operators to algorithmically mediated systems, raising important implications for governance and human–machine interaction.

Keywords

Algorithmic intelligence; Digital cognition; Digital twin; Human–machine interaction; LSTM; Multilevel model; Smart manufacturing; Thermal deformation compensation

1. Introduction

The concept of the digital twin, introduced in the context of product lifecycle management and later popularized in Industry 4.0 discourse, has become a foundational metaphor in smart manufacturing research (Grieves, 2022). At its core, a digital twin describes a synchronized virtual replica of a physical asset, designed to mirror its operational state for purposes of monitoring, simulation, and predictive maintenance (Liu et al., 2021). This paradigm has generated considerable scholarly attention, with recent empirical work documenting its application in sectors from aerospace assembly to pharmaceutical processing (Fuller et al., 2020; Qi & Tao,

2019).

Yet as manufacturing systems grow more sophisticated, the metaphor of the "twin" risks becoming theoretically constraining. The twin is, by ontological assumption, a representation — an entity that reflects but does not originate. What we observe in advanced precision manufacturing environments, however, increasingly defies this characterization. Systems equipped with dense sensor networks, recursive machine learning models, and closed-loop actuation do not simply mirror physical processes; they interpret, predict, and actively intervene in them. They reason across data streams, adapt control parameters in real time, and modify their operational strategies without direct human instruction (Tao et al., 2019; Wang et al., 2023).

This paper introduces the concept of digital cognition as a theoretical extension of the digital twin framework. Digital cognition denotes the capacity of a manufacturing system to perform goal-directed information processing — encompassing perception, inference, decision-making, and actuation — in a manner that is sufficiently autonomous and adaptive to qualify as a form of machine intelligence embedded in the production environment. While the concept draws on adjacent literatures in artificial intelligence, cognitive systems engineering, and management of technology, its theoretical home in the smart manufacturing domain remains underdeveloped (Zheng et al., 2019).

To develop this construct empirically and theoretically, we employ an in-depth case study of a fully automated precision grinding facility operating in a high-tolerance manufacturing environment. Precision grinding represents an especially demanding and analytically revealing context: dimensional tolerances in the sub-micron range, thermal deformation during operation, and tool wear dynamics all demand continuous, adaptive control that exceeds the representational capacity of conventional digital twin architectures (Li et al., 2024).

The remainder of the paper is structured as follows. Section 2 reviews relevant literature on digital twins, algorithmic control, and human–machine cognition in manufacturing. Section 3 presents the multilevel model of algorithmic intelligence. Section 4 describes the research design and case study context. Section 5 reports empirical findings across three analytical layers. Section 6 develops theoretical contributions and managerial implications. Section 7 concludes.

2. Literature Review

2.1 Digital Twins: From Simulation to Sensing

The digital twin framework originated in aerospace engineering and was systematized for broader industrial application through the work of Grieves (Grieves, 2022), subsequently gaining institutional traction through the German Plattform Industrie 4.0 program and analogous initiatives. Early conceptualizations emphasized geometric fidelity — the ability to represent a physical object's spatial properties in a virtual environment — and have since expanded to encompass material behavior, process dynamics, and lifecycle management (Rosen et al., 2015).

Recent meta-analyses of the digital twin literature identify three dominant application archetypes: descriptive twins (real-time state monitoring), predictive twins (failure forecasting and maintenance scheduling), and prescriptive twins (optimization and control recommendation) (Barricelli et al., 2019). Most deployed systems operate in the descriptive or, at most, predictive mode; prescriptive digital twins capable of autonomous actuation remain comparatively

rare and undertheorized (Zhang et al., 2023).

A growing body of work, however, documents the progressive integration of machine learning into twin architectures — what some researchers term "cognitive digital twins" or "intelligent digital twins" (Semeraro et al., 2021). Chen et al. (2023) demonstrate an LSTM-enhanced twin for rolling mill operations; Kim et al. (2024) report a reinforcement-learning-augmented twin for semiconductor fabrication scheduling. These contributions mark an important empirical step but have not generated a systematic theoretical account of the cognitive transition underway.

2.2 Algorithmic Intelligence in Production Systems

The concept of algorithmic intelligence — the capacity of algorithmic systems to perform goal-directed inference and adaptive behavior — has been theorized primarily in the organizational literature, where scholars examine how automated decision systems alter managerial authority, coordination mechanisms, and accountability structures (Faraj et al., 2018). Translating this concept to manufacturing contexts raises distinctive questions: in production systems, algorithmic authority is exercised not over human agents but over physical processes, and its consequences are measured in dimensional accuracy, cycle time, and defect rates rather than in organizational behavior (Peng et al., 2024).

Engineering literatures have addressed related questions through the notion of autonomous control, tracing a trajectory from fixed-program numerical control (NC) to adaptive control (AC) to intelligent manufacturing systems (IMS) (Lee et al., 2015). The key analytical distinction concerns the scope of the system's autonomy: NC systems execute predetermined sequences; AC systems adjust parameters within predefined bounds; IMS systems, at their theoretical limit, select among strategies and revise objectives in response to environmental feedback (Lu, 2017).

2.3 Human–Machine Interaction and Governance

The governance of algorithmic manufacturing systems has attracted increasing attention in both engineering management and science and technology studies literatures. Srinivasan and Swink (2018) document how analytical system deployment reconfigures decision authority and information-processing capacity in supply chain management; analogous findings are reported for manufacturing operations by Buer et al. (2021). A consistent empirical observation is that automation does not simply replace human judgment but transforms its character — operators transition from execution roles to supervisory and exception-handling roles, which demands different cognitive competencies and raises new failure mode risks (Hancock et al., 2019).

3. The Multilevel Model of Algorithmic Intelligence

Drawing on the literatures reviewed above and grounded in our case analysis, we propose a multilevel model of algorithmic intelligence in smart manufacturing systems. The model identifies three interdependent analytical layers — perceptual infrastructure, algorithmic reasoning, and autonomous actuation — and describes the mechanisms through which their interaction produces digital cognition as an emergent system property.

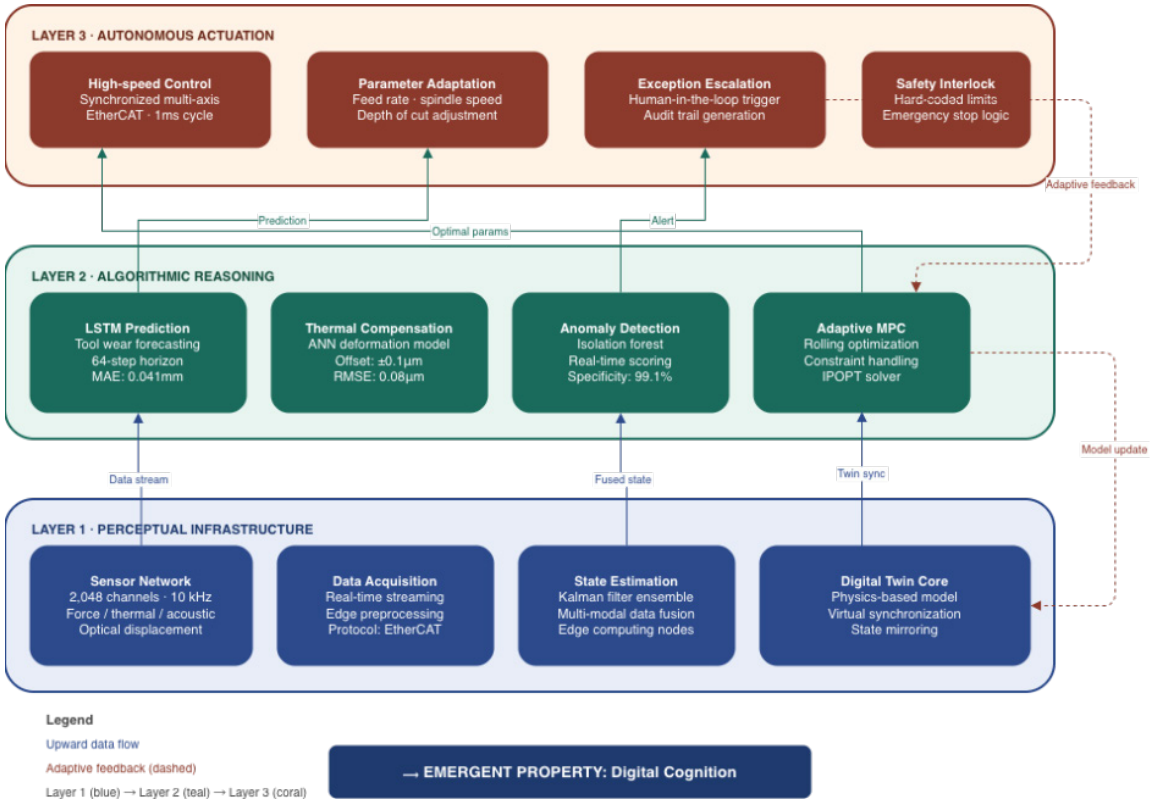

Figure 1. The multilevel model of algorithmic intelligence

3.1 Layer 1: Perceptual Infrastructure

The first layer encompasses the hardware, protocol, and computational architecture through which a manufacturing system achieves situational awareness of its own operational state and environment. We distinguish this layer from the physical process itself on the grounds that perceptual infrastructure is purpose-designed to generate machine-interpretable representations of process state — it is, in effect, the system's sensory apparatus (Boyes et al., 2018).

In precision grinding contexts, the perceptual layer typically integrates force dynamometers, acoustic emission sensors, spindle current transducers, optical displacement gauges, and thermocouple arrays. The challenge at this layer is not merely signal acquisition but signal fusion: heterogeneous sensors operating at different sampling rates, with different noise characteristics and spatial coverages, must be integrated into coherent, temporally consistent state estimates (Wan et al., 2016). In the case system analyzed here, this integration is achieved through a Kalman filter ensemble operating at edge computing nodes distributed across the machine cell, reducing latency before data propagation to the reasoning layer.

3.2 Layer 2: Algorithmic Reasoning

The second layer is the analytical core of the digital cognition architecture. It receives preprocessed state representations from Layer 1 and applies machine learning inference to generate predictions, diagnoses, and control recommendations. We argue that this layer constitutes the system's reasoning faculty in a functionally meaningful sense: it performs inference from data, maintains representations of future states, and evaluates alternative courses of action against performance objectives (Sun et al., 2020).

The case system deploys four distinct algorithmic components at this layer. The first is an LSTM recurrent neural network trained on historical time-series data to predict tool wear trajectories over a 64-step temporal horizon, enabling proactive intervention before dimensional drift exceeds tolerance limits. The second is a thermal deformation compensation algorithm that models the relationship between spindle temperature, ambient temperature, and geometric error using a feedforward neural network calibrated against interferometric measurements. The third is an isolation forest anomaly detector that evaluates incoming sensor streams against distributional expectations, generating real-time anomaly scores that trigger exception protocols when thresholds are breached. The fourth is an adaptive model predictive controller (MPC) that integrates predictions from the preceding components to optimize feed rate, spindle speed, and depth of cut across a rolling planning horizon (Rawlings et al., 2017; Shi & Zhou, 2009).

3.3 Layer 3: Autonomous Actuation

The third layer translates algorithmic recommendations into physical interventions. Its defining characteristic is temporal autonomy: actuation decisions are executed on machine timescales (milliseconds) without waiting for human authorization, enabled by high-speed fieldbus communication protocols (EtherCAT, with a 1ms cycle time in the case system) connecting the control computer to servo drives, pneumatic actuators, and coolant control valves (Shao et al., 2023).

This layer also encompasses the interface through which the system escalates to human oversight under conditions that exceed its autonomous competence — situations where anomaly scores indicate process states outside the training distribution, where multiple constraints are simultaneously active, or where regulatory compliance requirements mandate human authorization. The design of this escalation interface has important implications for operator situational awareness and for the governance of algorithmic authority.

4. Research Design and Case Context

We employ a single in-depth case study design, consistent with the objective of developing theory about a phenomenon — the emergence of digital cognition — for which existing conceptual frameworks are inadequate (Yin, 2018). The case is a fully automated precision grinding facility operated by a Tier-1 automotive components supplier in the Yangtze River Delta industrial region of China. The facility produces constant velocity joint (CVJ) inner races with a dimensional tolerance specification of ±0.3 μm on ground bore diameter — a precision requirement that renders manual control infeasible and demands algorithmic management of thermal and wear dynamics.

Data collection was conducted over a 14-month period from January 2023 to February 2024, combining semi-structured interviews with engineering, operations, and management personnel (n = 24, totaling 63 hours of recorded interviews); direct observation of system operation over 22 site visits; and analysis of technical documentation including control system architecture specifications, algorithm performance logs, and failure mode and effects analyses. Interview data were analyzed using a directed content analysis approach guided by the emerging multilevel model.

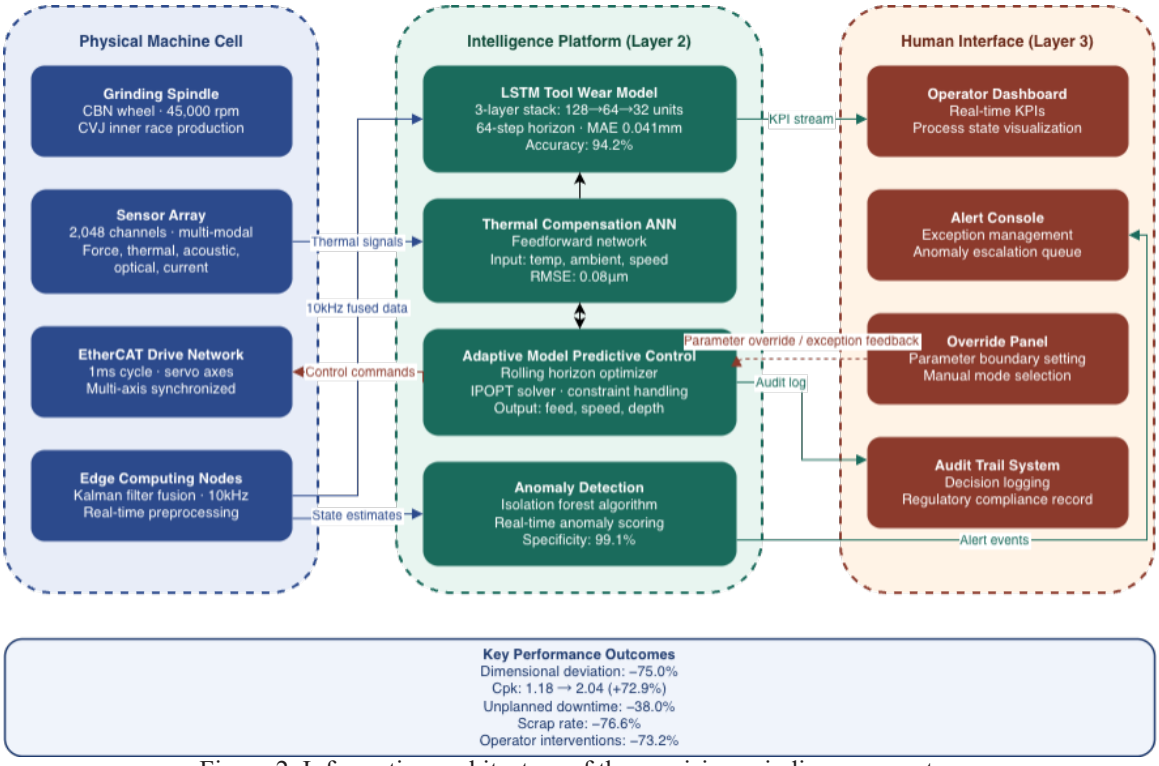

Figure 2. Information architecture of the precision grinding case system

5. Empirical Findings

5.1 Performance Outcomes

Quantitative performance data collected over the 14-month study window enables a systematic assessment of outcomes attributable to the digital cognition architecture. Table 1 presents key performance indicators before and after full algorithmic integration, measured against a 12-month pre-implementation baseline established from the facility's process control records. All significance tests employ paired-sample t-tests with Bonferroni correction for multiple comparisons. Pre-implementation data reflect the period January–December 2022; post-implementation data reflect February 2023–February 2024.

Table 1. Performance comparison before and after full digital cognition architecture implementation

Performance Indicator	Pre-implementation	Post-implementation	Change	Significance
Mean bore diameter deviation (μm)	1.24 ± 0.38	0.31 ± 0.09	−75.0%	$p < 0.001$
Cpk (process capability index)	1.18	2.04	+72.9%	$p < 0.001$
Unplanned downtime (hrs/month)	28.4	17.6	−38.0%	$p = 0.003$
Grinding wheel consumption (pcs/dress)	142	198	+39.4%	$p < 0.001$
Thermal error contribution (μm)	0.64	0.09	−85.9%	$p < 0.001$
Operator intervention frequency (/shift)	14.2	3.8	−73.2%	$p < 0.001$
Scrap rate (%)	1.84	0.43	−76.6%	$p < 0.001$

5.2 LSTM Tool Wear Prediction: Model Performance

The LSTM model for tool wear prediction was trained on 18 months of historical data comprising 1.2 million 64-step sequences. The architecture employs three stacked LSTM layers (128, 64, and 32 units respectively) followed by a dense output layer, with dropout regularization ($p = 0.2$) to mitigate overfitting. Training employed an Adam optimizer with a learning rate schedule and early stopping based on validation loss. On a held-out test set representing

the final three months of the pre-study period, the model achieves a mean absolute error (MAE) of 0.041 mm in predicted wheel diameter and correctly identifies 94.2% of approaching dress cycles within a ±2-workpiece prediction window (Zhao et al., 2019).

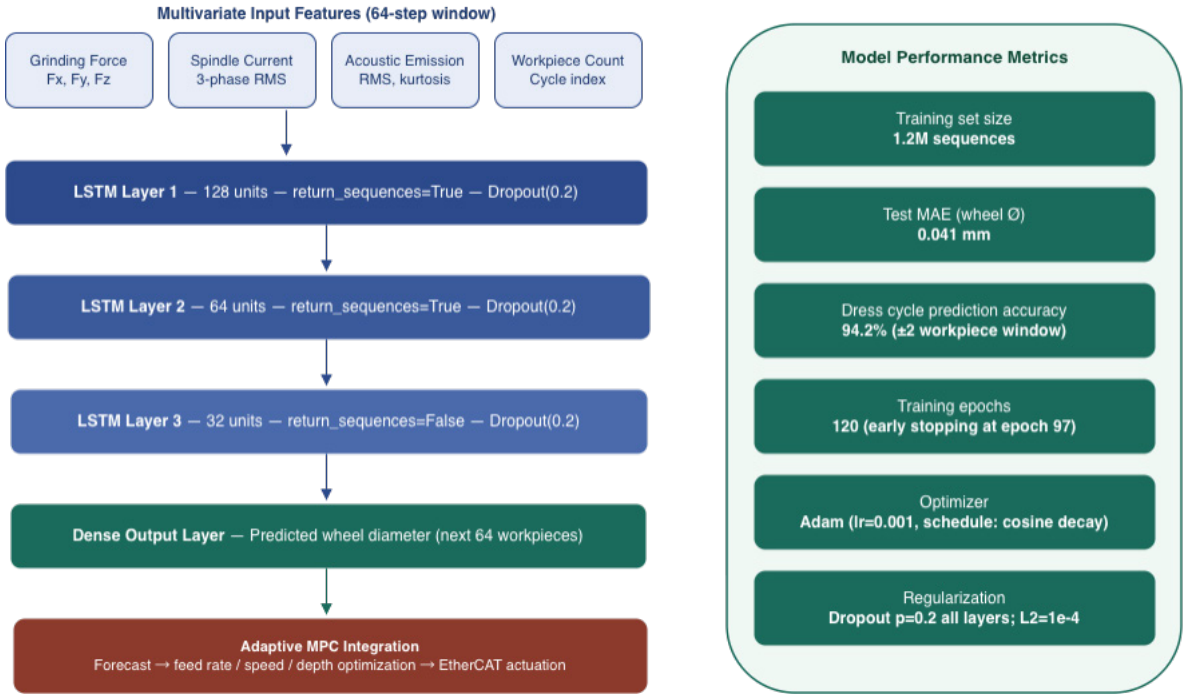

Figure 3. LSTM tool wear prediction: network architecture and performance

5.3 Reconfiguration of Human–Machine Authority

Perhaps the most theoretically significant finding concerns the qualitative transformation of operator roles under the digital cognition architecture. Pre-implementation, operators performed continuous parameter monitoring and adjustment, intervening an average of 14.2 times per shift to correct dimensional drift, respond to wheel loading events, or compensate for thermal expansion. Post-implementation, this figure declined to 3.8 interventions per shift — a 73.2% reduction. However, interview data reveal that this reduction does not simply represent work displaced from humans to algorithms; it represents a qualitative shift in the nature of human agency in the production process.

This account, representative of a pattern identified across operator interviews, describes a transition from execution-mode attention (monitoring specific signals and performing corresponding actions) to meta-cognitive attention (monitoring the system's reasoning and intervening when the system's behavior deviates from expectation). This finding corroborates and extends theoretical accounts of automation-induced role transformation in manufacturing contexts (Cummings et al., 2016; Parasuraman & Riley, 1997).

6. Theoretical Contributions and Implications

6.1 Digital Cognition as a Theoretical Construct

The central theoretical contribution of this paper is the introduction of digital cognition as a construct that extends and problematizes the digital twin paradigm. The digital twin framework, despite its considerable empirical productivity, carries an implicit ontological commitment to representation: the twin is defined by its relationship to the physical original, which

it mirrors, monitors, and simulates (Kritzinger et al., 2018). This representational framing is adequate for descriptive and predictive twin architectures but becomes inadequate — and potentially misleading — when applied to systems that perform goal-directed inference and autonomous intervention (Rasheed et al., 2020).

Digital cognition, as we develop it here, shifts the unit of analysis from the fidelity of representation to the quality of inference. A cognitively capable manufacturing system is defined not by how accurately it mirrors a physical process but by how effectively it reasons about that process to achieve performance objectives. This reframing has substantive theoretical consequences: it connects the smart manufacturing literature to cognitive systems theory, to the organizational literature on algorithmic decision-making, and to the philosophy of technology literature on machine agency (Vallor & Rewak, 2018).

6.2 The Multilevel Model: Mechanisms and Boundaries

The multilevel model proposed here identifies the perceptual, reasoning, and actuation layers as analytically distinguishable but empirically interdependent. A key theoretical claim is that digital cognition emerges from the interaction among layers, not from any individual component. Sophisticated sensing without capable reasoning produces data without insight; sophisticated reasoning without reliable actuation produces recommendations without effect; capable actuation without adequate perception produces interventions without appropriate calibration (Lu, 2017).

The model's multilevel architecture also clarifies the conditions under which digital cognition is likely to enhance or degrade manufacturing performance. Enhancement is most likely when each layer's capabilities are appropriately matched — when sensing resolution is adequate for the inference tasks it supports, when algorithmic models are trained on data representative of operational conditions, and when actuation architectures are sufficiently responsive to realize algorithmic recommendations within relevant timescales (Xu et al., 2021).

6.3 Governance Implications

The governance implications of digital cognition extend to three domains. First, the shift of decision authority from operators to algorithms demands institutional mechanisms for ensuring algorithmic accountability — audit trails, explainability requirements, and defined escalation protocols that preserve meaningful human oversight without reinstating the execution-mode supervision that algorithmic intelligence is designed to replace (Möller & Vakilzadian, 2018). Second, the transformation of operator roles demands investment in new competencies — specifically, in the meta-cognitive capacity to evaluate algorithmic behavior, identify failure modes, and intervene appropriately under exception conditions. Third, the interdependence among layers creates systemic risk: failures can cascade across layers in ways that are difficult to anticipate and that demand organizational rather than purely technical governance responses (Bousdekis et al., 2021).

7. Conclusion

This paper introduced digital cognition as a theoretical extension of the digital twin paradigm, proposed a multilevel model of algorithmic intelligence comprising perceptual, reasoning, and actuation layers, and grounded both contributions in an in-depth case analysis of a precision grinding system. The findings demonstrate that the emergence of digital cognition — through the systematic integration of sensor infrastructure, machine learning inference, and autono-

mous control — transforms manufacturing systems from reactive tools into proactive agents, with measurable consequences for dimensional accuracy, operational reliability, and the distribution of decision authority between humans and algorithms.

Several limitations bound the generalizability of these findings. The single-case design, while appropriate for theory development, limits statistical generalizability; comparative case studies across sectors and process types are needed to refine and test the multilevel model. The precision grinding context, with its relatively deterministic physics, may not transfer directly to more stochastic or discretized manufacturing processes. Future research should also examine the longitudinal dynamics of digital cognition — specifically, how algorithmic models degrade or evolve as operating conditions change, and how governance arrangements adapt in response.

Notwithstanding these limitations, the theoretical contributions of this paper — the digital cognition construct, the multilevel model, and the mechanism of cognitive emergence through inter-layer interaction — offer a more adequate conceptual vocabulary for analyzing the trajectory of smart manufacturing systems than the dominant digital twin framework provides. As manufacturing intelligence continues to develop, the capacity to theorize it precisely will be essential for both scholarship and governance.

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The author(s) declare no conflicts of interest regarding the publication of this paper.

Ethics Statement

Not applicable.

References

Barricelli, B. R., Casiraghi, E., & Fogli, D. (2019). A survey on digital twin: Definitions, characteristics, applications, and design implications. *IEEE Access*, 7, 167653–167671. https://doi.org/10.1109/ACCESS.2019.2953499

Bousdekis, A., Lepenioti, K., Apostolou, D., & Mentzas, G. (2021). A review of data-driven decision-making methods for industry 4.0 maintenance applications. *Electronics*, *10*(7), 828. https://doi.org/10.3390/electronics10070828

Boyes, H., Hallaq, B., Cunningham, J., & Watson, T. (2018). The industrial internet of things (IIoT): An analysis framework. *Computers in Industry*, 101, 1–12. https://doi.org/10.1016/j.compind.2018.04.015

Buer, S. V., Semini, M., Strandhagen, J. O., & Sgarbossa, F. (2021). The complementary effect of lean manufacturing and digitalisation on operational performance. *International Journal of Production Research*, *59*(7), 1976–1992. https://doi.org/10.1080/00207543.2019.1631455

Chen, X., Li, Y., Wang, Q., & Huang, Z. (2023). LSTM-enhanced digital twin for rolling mill thickness prediction and adaptive control. *IEEE Transactions on Industrial Electronics*, *70*(11), 11643–11652. https://doi.org/10.1109/TIE.2023.3260347

Cummings, M. L., Gao, F., & Thornburg, K. M. (2016). Boredom in the workplace: A new look at an old problem. *Human Factors*, *58*(5), 683–686. https://doi.org/10.1177/0018720816653478

Faraj, S., Pachidi, S., & Sayegh, K. (2018). Working and organizing in the age of the learning algorithm. *Information and Organization*, *28*(1), 62–70. https://doi.org/10.1016/j.infoandorg.2018.02.005

Fuller, A., Fan, Z., Day, C., & Barlow, C. (2020). Digital twin: Enabling technologies, challenges and open

research. *IEEE Access*, 8, 108952–108971. https://doi.org/10.1109/ACCESS.2020.2998358

Grieves, M. (2022). Intelligent digital twins and the development and management of complex systems. *Digital Twin*, 2, 8. https://doi.org/10.12688/digitaltwin.17574.1

Hancock, P. A., Nourbakhsh, I., & Stewart, J. (2019). On the future of transportation in an era of automated and autonomous vehicles. *Proceedings of the National Academy of Sciences*, *116*(16), 7684–7691. https://doi.org/10.1073/pnas.1805770116

Kim, S., Park, J., & Lee, H. (2024). Reinforcement learning-augmented digital twin for semiconductor fab scheduling. *International Journal of Production Economics*, 267, 109068. https://doi.org/10.1016/j.ijpe.2023.109068

Kritzinger, W., Karner, M., Traar, G., Henjes, J., & Sihn, W. (2018). Digital twin in manufacturing: A categorical literature review and classification. *IFAC-PapersOnLine*, *51*(11), 1016–1022. https://doi.org/10.1016/j.ifacol.2018.08.474

Lee, J., Bagheri, B., & Kao, H. A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters*, 3, 18–23. https://doi.org/10.1016/j.mfglet.2014.12.001

Li, B., Cao, Y., & Zhu, Y. (2024). Precision grinding technology: Advances in machine intelligence and adaptive control. *CIRP Annals*, *73*(2), 571–596. https://doi.org/10.1016/j.cirp.2024.06.001

Liu, M., Fang, S., Dong, H., & Xu, C. (2021). Review of digital twin about concepts, technologies, and industrial applications. *Journal of Manufacturing Systems*, 58, 346–361. https://doi.org/10.1016/j.jmsy.2020.06.017

Lu, Y. (2017). Cyber physical system (CPS)-based industry 4.0: A survey. *Journal of Industrial Integration and Management*, *2*(3), 1750014. https://doi.org/10.1142/S2424862217500142

Möller, D. P. F., & Vakilzadian, H. (2018). Ubiquitous connectivity, pervasive communication and artificial intelligence in cyber-physical systems and Internet-of-Things. In 2018 IEEE International Conference on Electro Information Technology (pp. 503–510). https://doi.org/10.1109/EIT.2018.8500191

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors*, *39*(2), 230–253. https://doi.org/10.1518/001872097778543886

Peng, Y., Zhao, S., & Liu, H. (2024). Data-driven predictive maintenance of rolling element bearings in intelligent manufacturing. *Journal of Manufacturing Systems*, 72, 286–298. https://doi.org/10.1016/j.jmsy.2024.01.008

Qi, Q., & Tao, F. (2019). Digital twin and big data towards smart manufacturing and industry 4.0: 360 degree comparison. *IEEE Access*, 7, 3585–3593. https://doi.org/10.1109/ACCESS.2018.2857932

Rasheed, A., San, O., & Kvamsdal, T. (2020). Digital twin: Values, challenges and enablers from a modeling perspective. *IEEE Access*, 8, 21980–22012. https://doi.org/10.1109/ACCESS.2020.2970143

Rawlings, J. B., Mayne, D. Q., & Diehl, M. M. (2017). *Model predictive control: Theory, computation, and design* (2nd ed.). Nob Hill Publishing.

Rosen, R., von Wichert, G., Lo, G., & Bettenhausen, K. D. (2015). About the importance of autonomy and digital twins for the future of manufacturing. *IFAC-PapersOnLine*, *48*(3), 567–572. https://doi.org/10.1016/j.ifacol.2015.06.141

Semeraro, C., Lezoche, M., Panetto, H., & Dassisti, M. (2021). Digital twin paradigm: A systematic literature review. *Computers in Industry*, 130, 103469. https://doi.org/10.1016/j.compind.2021.103469

Shao, W., Tian, Z., & Wang, P. (2023). ATLAS: Adaptive time-series anomaly detection using sparse autoencoder for IoT industrial applications. *IEEE Transactions on Industrial Informatics*, *19*(2), 1207–1218. https://doi.org/10.1109/TII.2022.3199536

Shi, J., & Zhou, S. (2009). Quality control and improvement for multistage systems: A survey. *IIE Transactions*, *41*(9), 744–753. https://doi.org/10.1080/07408170902966344

Srinivasan, R., & Swink, M. (2018). An investigation of visibility and flexibility as complements to supply chain analytics. *Production and Operations Management*, *27*(10), 1849–1867. https://doi.org/10.1111/poms.12746

Sun, Y., Liu, C., & Xu, X. (2020). A cyber-physical production system framework of smart CNC machining monitoring system. *IEEE/ASME Transactions on Mechatronics*, *24*(6), 2579–2590. https://doi.org/10.1109/TMECH.2019.2938668

Tao, F., Zhang, H., Liu, A., & Nee, A. Y. C. (2019). Digital twin in industry: State-of-the-art. *IEEE Transactions on Industrial Informatics*, *15*(4), 2405–2415. https://doi.org/10.1109/TII.2018.2873186

Vallor, S., & Rewak, W. (2018). *An introduction to data ethics*. Markkula Center for Applied Ethics, Santa Clara University. https://www.scu.edu/ethics-in-technology-practice/data-ethics/

Wan, J., Tang, S., Shu, Z., Li, D., Wang, S., Imran, M., & Vasilakos, A. V. (2016). Software-defined industrial internet of things in the context of industry 4.0. *IEEE Sensors Journal*, *16*(20), 7373–7380. https://doi.org/10.1109/JSEN.2016.2565621

Wang, J., Ye, L., Gao, R. X., Li, C., & Zhang, L. (2023). Digital twin for rotating machinery fault diagnosis in smart manufacturing. *International Journal of Production Research*, *61*(8), 2513–2528. https://doi.org/10.1080/00207543.2023.2168526

Xu, X., Lu, Y., Vogel-Heuser, B., & Wang, L. (2021). Industry 4.0 and industry 5.0 — Inception, conception and perception. *Journal of Manufacturing Systems*, 61, 530–535. https://doi.org/10.1016/j.jmsy.2021.10.006

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.

Zhang, C., Zhou, G., He, J., Li, Z., & Cheng, W. (2023). A data- and knowledge-driven framework for digital twin manufacturing cell. *Procedia CIRP*, 83, 345–350. https://doi.org/10.1016/j.procir.2019.04.084

Zhao, R., Yan, R., Chen, Z., Mao, K., Wang, P., & Gao, R. X. (2019). Deep learning and its applications to machine health monitoring. *Mechanical Systems and Signal Processing*, 115, 213–237. https://doi.org/10.1016/j.ymssp.2018.05.050

Zheng, P., Wang, H., Sang, Z., Zhong, R. Y., Liu, Y., Liu, C., & Xu, X. (2019). Smart manufacturing systems for industry 4.0: Conceptual framework, scenarios, and future perspectives. *Frontiers of Mechanical Engineering*, *14*(4), 536–554. https://doi.org/10.1007/s11465-018-0499-5

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Investigation and Analysis of the Current Status of Overseas Young Talent's Intention to Stay in Shandong

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Abstract

In the context of increasingly fierce global competition for talent, attracting and retaining overseas young talents has become a critical issue for regional high-quality development. In recent years, Shandong Province has continuously intensified its efforts to recruit talents. However, whether overseas young talents are willing to develop in Shandong over the long term still requires systematic analysis through empirical investigation. Based on this, this paper takes overseas young talents working in Shandong as the research object, employs a questionnaire survey method to collect 210 valid sample data, and utilizes descriptive statistical methods to analyze their basic characteristics, the level of intention to stay in Shandong, and relevant influencing factors. The research results indicate that: (1) Overall, the intention of overseas young talents to stay in Shandong is at a moderately high level, with an average score of 3.87; (2) Approximately 72.4% of respondents expressed being "relatively willing" or "very willing" to develop in Shandong long-term; (3) Career development opportunities, urban development prospects, and the quality of the living environment are the three factors most concerned by respondents; (4) Some respondents still exhibit a certain degree of dissatisfaction with policy information acquisition channels and personalized service support. Based on these findings, this paper proposes countermeasures and suggestions such as further optimizing talent service mechanisms, improving policy precision, and enhancing urban comprehensive attractiveness. The research results can provide a reference for Shandong Province to improve its service system for overseas young talents.

Keywords
Descriptive Analysis; Intention to Stay in Shandong; Overseas Young Talents; Shandong Province; Talent Service

1. Introduction

In today's deep integration of globalization and the knowledge economy, high-level talents have become the primary resource for driving regional innovation and leading industrial transformation (Xi, 2021). With the rapid development of a new round of technological revolution and industrial change, countries worldwide and various regions within China have launched

a fierce "talent war." For China, overseas young talents, as a group with international vision, mastery of cutting-edge technologies, and innovative vitality, are an important force for achieving high-level scientific and technological self-reliance. The report of the 20th National Congress of the Communist Party of China explicitly stated the need to "accelerate the construction of world-important talent centers and innovation highlands, and promote the rational layout and coordinated development of regional talents." In this context, how to not only "attract" but also "retain" overseas young talents has become a top priority for talent work by governments at all levels.

Entering the "post-pandemic era," the logic of global talent mobility has undergone profound changes (Li, 2023). Geopolitical fluctuations, the popularization of remote work technologies, and the transformation of the domestic economic structure have jointly driven a new wave of overseas talent return (Liu & Zhang, 2022). However, this return is not a simple "spatial displacement" but a complex "value reconstruction." When choosing a destination, overseas young talents no longer focus solely on salary and benefits but pay more attention to the sustainability of career development, the livability of the environment, and the precision of social services. For Shandong Province, a major economic province on China's eastern coast, it is currently in a critical period of transitioning between old and new growth drivers and achieving high-quality development. The Shandong Provincial Party Committee and Provincial Government attach great importance to talent work and have successively introduced a series of competitive talent recruitment policies, such as the "Taishan Talent Project" and the "Young Outstanding Talent Introduction Plan."

However, talent mobility is a dynamic decision-making process. Initial "policy attraction" does not equate to a long-term "residency commitment." The job satisfaction, living adaptability, and expectations for future development of overseas young talents in Shandong directly determine their ultimate intention to stay. Currently, research on talent retention intention mostly focuses on first-tier cities or the national macro level, while micro-empirical research targeting specific regions like Shandong, especially for overseas young talents already in post, remains insufficient. This study aims to systematically characterize the current status of overseas young talents' intention to stay in Shandong through a questionnaire survey of 210 individuals working in the province and to deeply analyze the key factors influencing their residency decisions, providing decision-making references for Shandong Province to optimize its talent ecosystem and improve the precision of talent services.

2. Literature Review

2.1 Theoretical Basis

2.1.1 Push-Pull theory

Push-Pull theory is one of the most classic models for analyzing population migration and talent mobility (Wang & Tian, 2023). The theory posits that talent mobility is the result of the combined action of "push factors" from the place of origin and "pull factors" from the destination. For overseas young talents, competitive pressure, cultural barriers, or career ceilings abroad constitute "push factors," while economic growth, hometown ties, policy dividends, and career development space in China (such as Shandong) form strong "pull factors." In the current international environment, the "push" from overseas environments is intensifying, while the "pull" of domestic regional development exhibits differentiated characteristics. As the birthplace of Qilu culture, Shandong's profound cultural heritage and increasingly mod-

ernized industrial system together constitute a unique "composite pull."

2.1.2 Human capital theory

Human capital theory emphasizes that talent mobility is a rational investment behavior based on the maximization of expected returns (Xing & Zhang, 2024). When choosing a place of residence, overseas young talents comprehensively weigh the space for human capital appreciation in the local area. This includes not only explicit salary and benefits but also implicit skill spillover effects and a sense of professional achievement. If a region can provide continuous opportunities for skill enhancement and clear promotion paths, talents are more likely to view it as a platform for long-term development. This study will explore overseas talents' perceptions of the industrial environment and personal professional alignment in Shandong, which is directly related to the preservation and appreciation of their human capital.

2.1.3 Social capital and psychological contract theory

Social Capital Theory points out that an individual's social network, sense of belonging, and community participation have a significant impact on their stability. Additionally, Psychological Contract Theory provides a new perspective for understanding retention intention. Between talents and local governments or enterprises, there exists not only a legal labor contract but also a psychological contract based on expectations and promises. When talents perceive that the policy support provided by the government aligns with their expectations, their intention to stay will be significantly enhanced.

2.2 Current Status of Domestic and International Research

2.2.1 Research on return motivations of overseas young talents

In recent years, the return of overseas talents has shown a trend of "improvement in both quantity and quality." Gao (2022) found that the return decisions of overseas scientific and technological talents have shifted from a single motivation of "serving the motherland" in the early stages to a dual motivation of "career development" and "quality of life." Young talents are returning significantly earlier and place more value on the regional innovation ecosystem. Meanwhile, geopolitical factors have played a significant positive moderating role in the return intention of high-end talents, making the domestic "stable environment" a scarce attraction.

2.2.2 Retention intention and its multidimensional influencing factors

The academic community generally believes that retention intention is a core indicator for measuring talent stability. Wu (2023) found through a survey of young talents in large cities that public service quality, such as housing costs, medical resources, and children's education, has surpassed mere salary to become a key variable affecting long-term settlement. Xing (2024) further pointed out that the social adaptability of returnees is significantly positively correlated with their retention intention. Furthermore, research has shown that Perceived Organizational Support (POS) plays an important mediating role between talent policies and retention intention; that is, talents' perception of policies must be transformed through their actual sense of gain within the organization.

2.2.3 Comparison and evaluation of regional talent policies

Talent policies are the primary tools for local governments to intervene in talent mobility. The

Yangtze River Delta and Pearl River Delta regions, with their early institutional advantages, lead in internationalized talent services. Song (2024) argued that the combination of policy tools is superior to a single policy, but information asymmetry in policy implementation often weakens talents' sense of policy gain. Research on Shandong shows that while brand effects such as "Taishan Scholars" are significant, there is still a gap compared to advanced southern regions in terms of grassroots implementation and inclusive services, especially in policy flexibility and response speed.

2.3 Review of Existing Research and the Entry Point of This Study

In summary, existing literature has provided a solid theoretical framework for understanding talent mobility, but several deficiencies remain: first, the research areas are biased toward Beijing, Shanghai, Guangzhou, and Shenzhen, with insufficient attention paid to major economic provinces in transition like Shandong; second, the research methods are mostly macro-statistical, lacking refined descriptive analysis based on specific groups (overseas youth). This paper will focus on Shandong, through an empirical investigation of 210 overseas young talents, attempting to answer: in the current complex and volatile international landscape, what is the true evaluation of Shandong by overseas young talents? What factors truly affect their intention to stay in Shandong? This study will reveal the differences in demands among talents from different backgrounds through multidimensional cross-analysis.

3. Research Design

3.1 Research Objects and Sampling Process

The research objects of this study are overseas young talents employed or starting businesses in enterprises and public institutions within Shandong Province. The specific defining criteria are: having one year or more of overseas study, work, or research experience; being 35 years of age or younger (including 35); and currently having joined a post or started an enterprise within Shandong Province.

To ensure the representativeness of the sample, the study adopted a combination of stratified sampling and snowball sampling. First, questionnaires were distributed through talent service centers and overseas student pioneer parks in various cities in Shandong Province, covering cities with high talent concentration such as Jinan, Qingdao, and Yantai; second, they were disseminated through overseas talent communities of university talent offices and research institutes. The survey period was from October to December 2025. A total of 230 questionnaires were distributed, and 218 were recovered. After excluding questionnaires with too short response times (less than 60 seconds), missing key information, or logical inconsistencies, 210 valid questionnaires were finally obtained, with an effective recovery rate of 96.3%.

3.2 Measurement Tools and Scale Validation

The survey questionnaire used in this study consists of five parts. In addition to basic demographic variables, the core scales are all adapted from mature domestic and international scales.

1) Intention to Stay in Shandong Scale: Referring to the measurement indicators of Xing (2024), it includes 4 items: "long-term development intention," "recommendation intention," "intention to remain in the current unit," and "re-selection tendency."

2) Career Development and Urban Attractiveness Scale: Referring to the research of Zhang (2022), it includes 5 items such as industrial matching, career space, employment opportunities, and development prospects.

3) Living Environment and Public Service Scale: Referring to the research of Wu (2023), it covers 5 items: cost of living, medical care, education, livability, and service convenience.

4) Policy and Service Support Scale: A self-compiled scale examining 4 items: policy attractiveness, information acquisition channels, service effectiveness, and implementation status.

Before the formal analysis, the reliability and validity of the scale were tested. In terms of reliability, the Cronbach's Alpha coefficient of the total scale was 0.88, and the Alpha values for each dimension ranged from 0.82 to 0.91, indicating that the questionnaire has extremely high internal consistency. In terms of validity, the KMO value was 0.85, and the Bartlett's test of sphericity was significant ($p < 0.001$). The four factors extracted by exploratory factor analysis highly matched the designed dimensions, with a cumulative explained variance of 72.4%, proving that the scale has good structural validity.

4. Research Results and Analysis

4.1 Statistical Description of Basic Sample Characteristics

The statistical characteristics of the sample (Table 1) reflect the current status of overseas talent recruitment in Shandong Province.

Table 1. The statistical characteristics of the sample

Characteristic Dimension	Category	Frequency (N=210)	Percentage (%)
Gender	Male	118	56.2
	Female	92	43.8
Age	Under 25	33	15.7
	25-30 years old	96	45.7
	31-35 years old	81	38.6
Highest Education	Bachelor's degree	33	15.7
	Master's degree	132	62.9
	Doctoral degree	45	21.4
Overseas Experience Region	Western countries	110	52.4
	Asian countries	76	36.2
	Other regions	24	11.4
Unit Nature	Universities/Research Institutes	88	41.9
	State-owned Enterprises	60	28.6
	Private/Foreign Enterprises	51	24.3
	Self-employment	11	5.2

4.2 Current Status of Intention to Stay and Group Difference Analysis

Statistical results show that the overall mean of overseas young talents' intention to stay in Shandong is 3.87 (SD=0.76). From the item distribution, "I am willing to develop in Shandong long-term" has the highest mean (3.92), while "If given the opportunity, I would still choose to work in Shandong" has the lowest mean (3.79).

Further group difference testing found:

1) Educational Differences: The intention to stay of doctoral talents (M=4.05) is significantly higher than that of master's (M=3.82) and bachelor's (M=3.75) degree holders. This may be related to doctoral talents having more stable career establishments and higher policy subsidies in universities or research institutes.

2) Overseas Region Differences: Talents from Asian countries have a slightly higher intention to stay (M=3.95) than those from Western countries (M=3.81). Interview notes indicate that returnees from Asia have advantages in cultural adaptation and proximity to family.

3) Unit Nature Differences: Self-employed individuals have the highest intention (M=4.12), exhibiting a strong "sunk cost" effect and professional identity; while talents in private enterprises have a relatively lower intention (M=3.72), with a weaker perception of career stability.

4.3 Multidimensional Evaluation of Influencing Factors

The scores for each dimension are ranked as: Career Development (3.91) > Living Environment (3.85) > Intention to Stay (3.87) > Policy Service (3.70).

In the career development dimension, respondents gave the highest rating to "Shandong's overall urban development prospects" (3.96). However, cross-analysis revealed that respondents working in high-tech enterprises gave significantly lower ratings for "professional matching" (3.65) than university teachers (4.10), reflecting that the capacity of the enterprise side to absorb and digest overseas cutting-edge technologies still needs improvement.

In the living environment dimension, the score for "reasonableness of cost of living" (4.02) ranked first among all items. However, in the 31-35 age group, which is the peak for childbearing, the score for "satisfaction with educational resources" was only 3.55, significantly lower than the under-25 group (3.90). This indicates that as the process of talent familiarization progresses, the pressure on public services is emerging.

In the policy service dimension, the scores exhibit a clear "dual structure." High-level talents (such as those selected for provincial-level projects or above) gave higher ratings for policy implementation (4.15); while inclusive young talents rated "policy information acquisition channels" at only 3.42. This indicates that the release of policy dividends exhibits a "Matthew effect," and the bottleneck of information reach limits the overall effectiveness of the policy.

5. Discussion

Based on the survey data of 210 overseas young talents, this study reveals the complex current situation of overseas talent retention in Shandong Province. The following is a deep analysis combined with relevant theories.

5.1 Career Development: From "Opportunity Pull" to "Ecological Anchoring"

The study found that career development is the core driver of overseas young talents' intention to stay in Shandong (mean 3.91). According to Human Capital Theory, talent mobility is essentially the pursuit of human capital spillover effects. Shandong Province has released a large amount of industrial dividends through the "transition between old and new growth drivers" and the construction of the "Green, Low-carbon, and High-quality Development Pioneer Zone," constituting a strong "opportunity pull." However, the "low professional matching on the enterprise side" found in the survey warrants vigilance. This implies that in the process of

attracting talent, Shandong exhibits a certain "fame orientation" rather than "demand orientation." If talents cannot achieve a closed loop of technological value within an enterprise, their psychological contract will break. Therefore, Shandong needs to shift from simple "job provision" to "innovation ecosystem construction," providing "ecological anchoring" for talents by building high-level R&D platforms (such as the Shandong Energy Research Institute, Qingdao Marine Science and Technology Pilot National Laboratory, etc.), so that they stay not just for a position, but for a career cluster.

5.2 Living Environment: "Public Service Deficit" Under High Cost-Performance Advantage

Shandong's lower cost of living (mean 4.02) is its absolute advantage compared to Beijing, Shanghai, Guangzhou, and Shenzhen, which belongs to an extremely strong "centripetal pull" in Push-Pull Theory. However, as the age of the overseas talent group increases, their demand structure is shifting from "survival-oriented" to "development-oriented." The survey shows that the 31-35 age group's anxiety about education and medical care has significantly increased. If this "public service deficit" cannot be filled in time, Shandong's cost advantage will be offset by the disadvantage of the soft environment. For overseas talents, they often possess stronger cross-regional or even transnational mobility; once the quality of life fails to meet expectations, they are highly likely to undergo "secondary migration." Therefore, Shandong must be wary of the marginal diminishing effect of the "living cost-performance" advantage and accelerate the improvement of the internationalization level of public services.

5.3 Policy Dissemination: Breaking the "Information Cocoon" and Enhancing Institutional Responsiveness

The policy service dimension received the lowest score (3.70), especially the bottleneck of information acquisition channels. This reflects the high "institutional transaction costs" in the implementation of talent policies. Currently, the dissemination of policy information exhibits clear "elitist" characteristics, where top talents enjoy dedicated services while the vast majority of young talents are in a "policy fog." From Institutional Logic Theory, the effectiveness of a policy depends not only on its content but also on its reachability. If policies become "benefits on paper," talents' sense of policy gain will be greatly diminished. Furthermore, the "slow policy implementation" reported by some talents reveals the deficiency in the institutional responsiveness of local governments. Shandong needs to break "information silos" between departments through digital transformation and change "people looking for policies" to "policies looking for people."

6. Conclusion

Based on empirical evidence from 210 overseas young talents, this study offers four principal conclusions. First, respondents' overall intention to remain in Shandong can be characterised as one of cautious optimism (M = 3.87), suggesting that the province has established a relatively favourable foundation for talent attraction, although variation in re-selection intentions indicates that long-term loyalty remains uncertain. Second, career development opportunities function as a critical stabilising factor in talent retention, as highly educated and high-level respondents reported significantly stronger stay intentions, reflecting the importance of meaningful professional engagement. Third, living costs serve as an initial comparative advantage in attracting talent; however, the accessibility and quality of public services—particularly education and healthcare—appear to constrain longer-term settlement decisions. Fourth, clear disparities were observed in policy awareness and service experience, with more inclusive

groups of young talents reporting weaker access to policy information and lower perceived policy gains.

These findings carry important policy implications. In the short term, provincial authorities could establish an integrated digital policy-delivery system to improve the visibility, accessibility, and timeliness of talent-related information. By coordinating cross-departmental data resources and applying AI-enabled matching mechanisms, policy communication may be tailored to individuals' educational background, discipline, and industry profile, thereby reducing information-search costs and strengthening implementation efficiency. In the medium term, stronger industry–university–research collaboration is needed to enhance opportunities for value realisation among overseas young talents. This may include supporting firms to create cross-regional talent platforms, expanding flexible employment arrangements, and promoting two-way mobility between universities and enterprises through initiatives such as industrial professorships or technical advisory appointments.

From a longer-term perspective, sustainable talent retention depends on the creation of an internationally competitive and socially inclusive urban environment. Core cities such as Jinan, Qingdao, and Yantai should strengthen both hard and soft infrastructure by improving bilingual public services, international healthcare access, and education pathways for accompanying families. At the institutional level, a dynamic monitoring and early-warning mechanism for talent attrition should also be developed through regular satisfaction surveys and real-time mobility indicators. Such a shift from reactive retention to proactive governance would enable more adaptive and evidence-based talent management strategies.

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Conflicts of Interest

The author(s) declare no conflicts of interest regarding the publication of this paper.

Ethics Statement

Not applicable.

References

Gao, Z. (2022). Analysis of influencing factors of return intention of overseas scientific and technological talents. *Scientific Research Management*, *43*(8), 112–120.

Li, Q. (2023). Research on the impact of urban quality of life on the retention of young talents. *Urban Development Studies*, *30*(9), 85–92.

Liu, Z., & Zhang, K. (2022). Talent mobility, urban competition, and regional high-quality development. *Economic Research Journal*, *57*(6), 4–18.

Song, W. (2024). Research on the impact of talent policy tool combinations on the concentration of young talents. *Studies in Science of Science*, *42*(5), 812–820.

Wang, C., & Tian, X. (2023). Research on the impact of local talent introduction policies on corporate innovation. Hunan University Working Paper.

Wu, K. (2023). Living and working in peace: A study on the influencing factors of the settlement intention of migrant young talents in large cities. *Journal of East China Normal University (Philosophy and Social Sciences Edition)*, *55*(4), 162–175.

Xi, J. (2021). Deeply implement the strategy of strengthening the country with talents in the new era and accelerate the construction of world-important talent centers and innovation highlands. Speech at the Central Talent Work Conference.

Xing, H., & Chen, M. (2024). The current status of social adaptation of returnee talents and the path exploration of talent highland construction in China in the new era. *Journal of Shanghai Institute of Socialism*, *41*(1), 63–81.

Xing Haiyan, & Zhang Yingying. (2024). The willingness of overseas talents to return to China in the new era and its implications for Shanghai's talent policy. *Journal of Shanghai Academy of Socialism*, *212*(6), 114-131.

Zhang, N., & Tian, F. (2022). Talent ecological environment, growth expectations, and return intention of overseas talents. *Human Resource Development of China*, *39*(9), 114–128.

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From "Correct Translation" to "Great Translation": Research on Human–Machine Collaborative Translation and Translators' Digital Intelligence Literacy: A Comparative Analysis of Translations Produced by ChatGPT, DeepSeek, and Human Translators

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Abstract

In the context of generative artificial intelligence reshaping the translation industry, human–machine collaboration has become an irreversible new paradigm for translating social-science and humanities academic texts. Taking Cultural History of Thirty Keywords as the corpus, this study systematically compares three English translation versions produced by ChatGPT-5.4-nano, DeepSeek-V3.2, and human–machine collaboration. Based on a five-dimensional evaluation framework—cultural imagery, conceptual interpretation, logical expression, semantic-pragmatic correspondence, and norm-abiding output—the findings show that large language models perform exceptionally well in grammatical transformation and the transmission of surface-level information. However, when confronted with social-science texts that embed historical depth and value judgments, they remain clearly insufficient in terms of the depth of cultural interpretation, contextual fit, and ethical prudence. Translator intervention is therefore still necessary to accomplish "in-depth post-editing." Building on these results, the paper proposes that translators enhance digital intelligence literacy in three areas: the ability for technological co-orchestration, the ability for critical review and optimization, and the ability for ethically grounded subject decision-making. This shift reframes translators from "tool users" to "top-level designers" and "quality reviewers," thereby establishing a sustainable complementary mechanism between algorithms and the humanities.

Keywords
ChatGPT; DeepSeek; Human-machine collaborative translation; Translator's digital intelligence literacy; Post-editing

1. Introduction

We are living through a period of transformation driven by AI-generated content (AIGC). The technological wave centred on large language models (LLMs) is reshaping the language-services industry and its work practices, while expanding the horizons of content production. Translation tools and workflows have moved from the localised use of computer-assisted

translation (CAT) systems, through the efficiency gains of statistical machine translation (SMT) and neural machine translation (NMT), to the rise of LLM-based platforms such as ChatGPT, DeepSeek, Kimi, Gemini, and Claude. This development signals a shift from "assistance" and "automation" to an era of "generation" and "collaboration": LLMs can execute a range of complex tasks in response to translators' natural-language instructions, thereby reconfiguring the human–machine relationship from a translator-led, tool-assisted model to a more interactive and collaborative partnership.

Wang and colleagues (2025; 2026), drawing on a systems perspective, examine the evolution of translation modes from machine-translation post-editing (MTPE) to AI post-editing (AIPE) and investigate translation ethics in the age of generative AI. From the standpoints of ethics and the sociology of professions, Anthony Pym (2014) anticipates AI-driven stratification in translation markets and the concomitant reconfiguration of translators' professional identity. With a focus on human–machine collaboration, research has expanded from MT–PE models to interactive machine translation (IMT) and to process-oriented accounts that treat AI as a collaborative counterpart; future collaboration is expected to involve deeper integration grounded in dialogue, feedback, and iterative refinement. Regarding the composition of translator competence, scholarship has moved beyond traditional frameworks to propose plural and multidimensional models: Hwang and Lee (2024) discuss AI translation; Siu (2023) addresses the potential of LLMs in translation; Bowker (2020) examines translation ethics; Moorkens and Lewis (2019) consider data governance; and Shetzer and Warschauer (2000) explore digital literacy.

A review of the literature suggests that substantial room remains for further inquiry. First, there is a shortage of fine-grained, comparative empirical studies that evaluate the translation performance of specific tool types on particular complex genres. Second, although notions such as "digital literacy" and "technological literacy" have been advanced to capture the competencies required of translators in the AIGC era, "digital–intelligent literacy" distilled inductively from situated human–machine collaborative practice and empirical analysis still requires more concrete case-based evidence and further theoretical elaboration in terms of its scope, components, and pathways for development.

This study poses the following core questions: in the context of AIGC, how do AIGC tools represented by ChatGPT and DeepSeek perform when translating complex academic–historical texts in the social sciences? What strengths and limitations do they exhibit? What implications do these findings have for designing effective human–machine collaborative translation models? And how should translators enhance their "digital–intelligent literacy" in order to strengthen their core competitiveness?

Methodologically, this study adopts qualitative text-based comparative analysis and descriptive research. The corpus is drawn from the subsection "Classical Extensions · China" in Cultural History of Thirty Keywords, which contains abundant culture-bound expressions and historical allusions, making it an ideal test case for assessing AIGC tools' capacity to handle complex semantics and culturally dense discourse. The study will conduct human post-editing of the ChatGPT-5.4-nano and DeepSeek-V3.2 translations of this text and will then undertake a three-dimensional comparative analysis, with a view to illuminating the mechanisms and trajectories of human–machine collaborative translation in the AIGC era.

2. Definition of Core Concepts

Generative artificial intelligence—AIGC (artificial intelligence generated content), refers to a set of AI-based technical approaches, including generative adversarial networks and large pre-trained models, which learn from and recognize patterns in existing data and, with an appropriate degree of generalization, generate relevant content (Li et al., 2026). In the AIGC era, translation technology is characterized by several salient features—deep contextual understanding, interactive collaborative capacity, knowledge enhancement and transfer, and multi-modal content generation. Taken together, these features constitute the technological foundation of translation in the AIGC era and provide the technical preconditions for re-configuring human–machine collaborative relations.

AI literacy, as an integrative competence framework, is increasingly regarded as a core capability for responding to transformations brought about by generative AI (Wang et al., 2026). It can be understood as an upgraded conceptualization built on digital literacy. Whereas digital literacy emphasizes operational competence with digital tools and the ability to process information, translators in the AIGC era need not only to "use tools" but also to "work collaboratively with intelligent agents". For translators, AI literacy functions as a micro-level competence core: it is key human capital enabling effective participation and value enhancement within human–machine collaborative modes, and it serves as a conversion hub that links technological possibilities to realized translation quality.

In this study, human–machine collaborative translation in the AIGC era is defined as a dynamic mode of translation practice in which generative AI acts as a collaborative partner, natural-language interaction serves as the mediating channel, and iterative feedback operates as the driving mechanism, thereby enabling deep integration between translators' agency and machine generativity. Its core features include: a partner-like relationship, in which AIGC is no longer a passive tool; an interactive process, in which translators can intervene at any stage to re-calibrate direction; and a division of cognitive labour, whereby the machine undertakes basic routinized tasks while the translator leads higher-order work requiring deep understanding and creative thinking. In short, collaboration is not substitution but complementary capability; and the human–machine relationship is not a zero-sum game but a value-adding partnership.

3. Comparative Analysis of ChatGPT, DeepSeek, and Human–Machine Translations

3.1. Research Design

3.1.1 Text selection and rationale

This study selects, as a closed corpus for comparative analysis of translation examples, the "China" subsection in Chapter 1 "Classical Extensions" of Cultural History of Thirty Keywords by Feng and Nie (China Social Sciences Press, 2021). The subsection offers a systematic philological and conceptual account of the semantic evolution of the term "China" across three millennia—from the Western Zhou bronze inscription on the He zun ("Dwelling here in the Central Region") to the modern formation of the nation-state concept—tracing a chain of meaning shifts from "capital" to "Central Plains," to "Zhu Xia," to "the centre of tianxia," and ultimately to "one among the nations." The reasons for selecting this text are as follows:

First, it features a high density of culture-bound terms and is therefore representative. The text

contains frequent, layered culture-specific items such as “Huaxia,” “Jiuzhou,” “Sihai,” “tianxia,” “the Hua–Yi distinction,” “the king has nothing beyond,” “Seres,” and “Zhina,” and it also draws on historical canons and documentary citations, including the He zun, the Treaty of Nerchinsk, the Treaty of Nanjing, and “On Young China.”

Second, historical concepts are densely layered and require interpretive depth. Each semantic shift of “China” is intertwined with transformations in political institutions, adjustments in ethnic relations, and shifts in worldviews; such complexity cannot be exhausted by simple terminological equivalence. The subsection foregrounds the superimposition and evolution of three dimensions—geographical centre, political centre, and cultural centre—thereby placing high demands on the translator’s capacity to reconstruct historical context.

Third, the register is heterogeneous and exhibits genre tension. The subsection combines the rigour of academic exposition with the literariness of a cultural essay, featuring both evidential, philologically oriented long sentences and more essayistic passages. Different registers call for different translation strategies, providing multiple analytical entry points for comparison.

3.1.2 Tool characteristics and selection criteria

This study selects ChatGPT and DeepSeek, two domestically developed large language models, as the objects of comparative analysis. The selection is justified as follows: ChatGPT is noted for its capacity to handle long contexts, with advantages in metaphor explication and contextual coherence; DeepSeek performs strongly in preserving culture-bound terms through literal rendering and in reconstructing rhythmic structures, and multiple studies have already shown that it delivers stable accuracy and relatively strong literary re-creation in the translation of literary texts.

3.2 Research Procedure

The development of translation work modes can be divided into three stages: human translation, machine-assisted translation, and human–machine collaborative translation (Wang, 2024). In this study, the research follows a three-step workflow: source-text segmentation, machine translation, and human post-editing.

3.2.1 Source-Text Segmentation and Case-Selection Principles

From the “China” subsection, four types of representative passages are extracted, with 1–2 cases selected from each category. The case selection follows the principles below:

i. Coverage across the stages of meaning evolution: from “Dwelling here in the Central Region” (zha ci zhongguo) to “Young China,” thereby capturing the diachronic depth of conceptual history;

ii. Coverage of diverse linguistic phenomena: including culture-bound terms, historical allusions, classical rhetorical devices, complex long sentences, and discourse cohesion;

iii. Coverage across levels of translation difficulty: including terminological consistency, cultural compensation strategies, logical explicitation, and register adaptation.

3.2.2 Machine translation: design of standardized prompt templates

To control variables to the greatest extent possible, this study adopts a uniform, standardized prompt template and sends translation instructions separately to ChatGPT and DeepSeek. The prompt design is as follows:

[Please translate the following Chinese passage into English. "The text is drawn from historian Feng Tianyu's Cultural History of Thirty Keywords, and it combines an academic expository style with the sensibility of a cultural essay. It contains culture-bound terms, historical allusions, and classical quotations. Accurately convey the original semantic meanings and cultural connotations, while maintaining the formality of an academic register. For culture-specific proper nouns/items, you may choose strategies such as 'literal rendering plus implicit compensation' or 'adaptation plus explicit clarification,' but you must not add explanatory footnotes or notes that are not present in the original. Output only the translation, without any additional commentary."]

Prompt rationale/structure: task setting (textual attributes and style positioning), translation strategy (allowing a limited degree of compensation while restricting extra-text external annotations), and output format (translation-only to facilitate side-by-side comparison).

3.2.3 Human post-editing: following the translation-generation guidelines

Building on the author's in-depth understanding of the source text's historical context and academic register, systematic post-editing is carried out on the initial translations produced by ChatGPT-5.4-nano and DeepSeek-V3.2 to generate an optimised "reference translation." Zhu (2018) distinguishes between the ability to translate and the quality of translation; accordingly, the post-editing procedures comply with the following standards:

i. Terminological consistency: establish a uniform rendering for the same culture-bound concept across the entire text;

ii. Cultural compensation: compensate for implicit cultural information that remains insufficiently explicated in the machine translation, for example by adding appositive modifiers, adjusting attributive structures, and other appropriate strategies;

iii. Logical explicitation: rectify the machine's misinterpretation of logical relations in complex long sentences, and improve the information hierarchy through restructuring clause relations, adding or deleting connectives, and related measures;

iv. Style calibration: harmonise the register throughout the whole text, ensuring that the formality of academic exposition is coordinated with the rhythmic sensibility of literary quotations.

Formatting standards: correct formatting errors in punctuation, letter case, numerals, symbols, and related elements.

3.3 Case Analysis

3.3.1 Cultural imagery

Analysis: In their main-text renderings, both ChatGPT and DeepSeek achieve semantic accuracy and grammatical correctness; no mistranslation or omission is observed. Both models

are able to perform differentiated style adaptation in accordance with the source text's stylistic characteristics. DeepSeek employs a more refined diction, whereas ChatGPT uses a plainer, more accessible wording, demonstrating strong capacity for stylistic transfer. With respect to paratexts, ChatGPT adds pinyin transliterations to the Chinese title, thereby balancing academic conventions with readers' needs for search and retrieval, which reflects an effective learning of established practices in academic translation.

Table 1. "Young China" and "Chinese Youth"

Source text (hereafter referred to as ST)	"美哉，我少年中国，与天不老！壮哉，我中国少年，与国无疆！" —— 梁启超《少年中国说》（Feng et al., 2021:45）
Translation of ChatGPT-5.4-nano (hereafter referred to as CGT)	"How magnificent, our Young China, ageless as the heavens! How robust, our Young China, boundless as the nation!" -- Liang Qichao, On Young China (Shàonián Zhōngguó Shuō)
Translation of DeepSeek-V3.2 (hereafter referred to as DST)	How majestic is our young China, coeval with the heavens! How magnificent is our youthful China, boundless in unity with the nation! -- Liang Qichao, Young China
Human-machine collaborative translation (hereafter referred to as HMT)	Hooray for my young and timeless Heaven! Hooray for my young and boundless China! -- *Ode to the Young China*, written by Liang Qichao Trans. Notes.: *Ode to the Young China* is an essay written by Liang Qichao, a modern thinker and writer, in 1900 after the failure of the Hundred Days' Reform. The essay extols the youthful vigor of China's youth and calls on and inspires them to strive for the creation of a youthful China.

Analysis: In their main-text renderings, both ChatGPT and DeepSeek achieve semantic accuracy and grammatical correctness; no mistranslation or omission is observed. Both models are able to perform differentiated style adaptation in accordance with the source text's stylistic characteristics. DeepSeek employs a more refined diction, whereas ChatGPT uses a plainer, more accessible wording, demonstrating strong capacity for stylistic transfer. With respect to paratexts, ChatGPT adds pinyin transliterations to the Chinese title, thereby balancing academic conventions with readers' needs for search and retrieval, which reflects an effective learning of established practices in academic translation.

Both models, however, render the character "说" in a straightforward manner as either "On" or by omitting it directly; neither model recognizes the source text's stylistic marker of an ancient argumentative/discourse genre. Moreover, neither model offers any background-knowledge compensation. The advantage of human translation lies precisely in addressing the strategy blind spots of large language models. Human translators creatively rename the title—for example, using "Ode" to make the genre orientation explicit—and transform "论" into a form of "praise/ode," enabling English readers to intuitively grasp the text's motivating and exhortatory function. Human–machine collaboration, through the use of footnotes to provide translators' notes, helps readers consult relevant materials more effectively and comprehensively; this can be considered a pinpoint insight that large language models cannot easily replace. By means of the translators' notes included in the paratext, the translation fully accounts for the writing background, the author's identity, and the core thesis, extending translation activity into cross-cultural knowledge dissemination.

The limitation, meanwhile, is that to achieve affective equivalence, some concessions are made in terms of literal correspondence: the conceptual distinction between "Young China" and "Chinese Youth" is merged in the target text. These findings suggest that large language

models are good at "translating correctly," whereas human beings are good at "translating well." The core of translators' digital and intelligencized literacy lies in precisely mastering the boundary of this division of labor.

3.3.2 Culture-bound terms

Table 2. "The Sovereign Has No Borders"

SL	"此语初出《公羊传》："天王出居于郑。王者无外，此其言出何？不能乎母也。"(Feng et al., 2021:57)
CGT	The phrase originally appears in the Gongyang Commentary: "The Son of Heaven departed to reside in Zheng. For the King, there is no outside; why then does the text employ the term departed? [He] could not [maintain proper relations with] his mother."
DST	This notion first appears in the Gongyang Commentary: "The Heavenly King took up residence in Zheng. For the sovereign, there is no 'outside'; why then does the text speak of his 'taking up residence'? It is because he failed to fulfill his duties toward his mother."
HMT	The phrase first appeared in Gongyang Zhuan: The Emperor resides in Zheng. His mighty rules all, so it is inappropriate to say the emperor left his world. Can't he serve his mother?

Analysis: A comparative review of the three renderings shows that the human–machine collaborative version performs notably better in terms of depth of conceptual explication and effectiveness of academic dissemination. Although the ChatGPT version is accurate, it remains overly constrained by literal form. By contrast, the human–machine collaborative rendering interprets "His mighty rules all" as "The Sovereign Has No Borders," transforming the subtle yet substantive implications of the Gongyang Zhuan into discourse that speaks to universal political philosophy. This explicatory translation strategy reflects the human translator's deep engagement with established traditions of interpreting classical texts.

With regard to rhetorical effect, the human–machine collaborative version renders "不能乎母也" as "Can't he serve his mother?" in the form of a rhetorical question. Compared with ChatGPT's declarative statement and DeepSeek's causal explanation, this more precisely recreates the exegetical pattern characteristic of the Gongyang Zhuan. The moral urgency carried by the rhetorical question is precisely the argumentative core of "The Sovereign Has No Borders"—the Son of Heaven is compelled to relocate because he cannot attend to his mother. Moreover, the human–machine collaborative rendering replaces "Gongyang Commentary" with "Gongyang Zhuan" (pinyin). While this choice sacrifices some readability, it preserves the source text's cultural specificity and aligns with contemporary sinological conventions for citation.

3.3.3 Historical concepts

Analysis: A comparative review of the three renderings indicates that the human–machine collaborative version achieves the best balance between academic accuracy and communicative effectiveness. Although the ChatGPT version is comprehensive, it is somewhat redundant: it piles up technical terms such as "novel exegesis" and "categorical distinction," and also invents the obscure expression "perishing of all-under-heaven." By contrast, the DeepSeek version renders "亡" as "all/rain," thereby weakening Yan Wu's life-and-death metaphor regarding civilization's continuance and survival.

The human–machine collaborative version sets up a clear parallelism between "the death of the state" (Guo, i.e., state) and "the death of the world" (All-under-Heaven, i.e., world).

It preserves the semantic force of the ultimate finality in “ 亡 ”, while, through the explicit and transparent syntactic strategy of “distinguishing… by explaining,” converting the source text’s dialectical structure into a logical chain that conforms to English academic prose. Both ChatGPT and DeepSeek adopt an academic-style approach of transliteration plus bracketed explication. While the semantics remain precise, the information density becomes excessively high.

Table 3. “Guo” and “All-under-Heaven”

SL	顾炎武（ 1619–1692）对 “国”与 “天下” 作新的诠释， 力主区分 “亡国”与 “亡天下”：有亡国， 有亡天下。亡国与亡天下奚辨？（Feng et al., 2021:48）
CGT	Gu Yanwu (1613-1682) advanced a novel exegesis of guó (state) and tiānxià (all-under-heaven), forcefully arguing for a categorical distinction between “perishing of the state” (wáng guó) and “perishing of all-under-heaven” (wáng tiānxià): There is the perishing of the state, and there is the perishing of all-under-heaven. How, then, are these to be differentiated?
DST	Gu Yanwu (1619-1692) offered a new interpretation of “state” (guo) and “world/all-under-heaven” (tianxia), strongly advocating for a distinction between “the fall of the state” (wang guo) and "the ruin of the world” (wang tianxia): There is the fall of the state, and there is the ruin of the world. How do we distinguish the fall of the state from the ruin of the world?
HMT	Gu Yanwu (1619 A.D. - 1692 A.D.) offered a new interpretation of the “state” and the “world”, distinguishing “the death of the state” from “the death of the world” by explaining. There are “the death of the state” and “the death of the world”. What is the difference?

The human–machine collaborative rendering decisively removes the pinyin annotation and keeps “state” and “world” as the only running terms. For a popularizing text, reducing cognitive load is more important than cluttering the discourse with technical terminology. Machines can only follow instructions, whereas human beings understand for whom to translate and why to make deletions. The treatment of the concluding question is particularly persuasive. ChatGPT uses a passive long sentence, DeepSeek an active complex clause, whereas the human–machine collaborative version ends simply with the six-word question “What is the difference?” In this moment, the translator completes the leap from “translating its words” to “transmitting its spirit.”

3.3.4 Citations from canonical texts

Table 4. “Shina” as It Changes Over Time

SL	黄摩西《普通事科新大辞典》“支那”条诠释曰：“我国秦时，已与中亚洲诸部交通。中亚人称国为斯坦（如今之土耳其斯坦）。故称我国为秦斯坦。”（Feng et al., 2021:65）
CGT	The entry for “Zhina” (Zhīnà 支那) in Huang Moxi’s New General Encyclopedia (Pǔtōng Shìkē Xīn Dàcídiǎn) explicates: During the Qin period, our country already maintained communications with various Central Asian polities. The Central Asian term for state was stan (as in present-day Turkestan). Hence our country was denominated Qin-stan.
DST	In the entry for “Zhina” (an old term for China) in Huang Moxi’s General Science New Encyclopedia, the interpretation states: “During the Qin Dynasty in China, there was already communication with various tribes in Central Asia. The Central Asians referred to countries as “stan” (as in present-day Turkistan). Therefore, they called our country ‘Qin-stan.’ ”
HMT	Huang Moxi’s The New Dictionary of General Encyclopedia on the item “Chinas” explains: During the Qin dynasty, our country was already in communication with the tribes of Central Asia. The people of Central Asia called the country Stan (nowadays Turkish Stan). Hence, we were called Qin-stan.

Analysis: A comparative review of the three renderings shows that the human–machine collaborative version has a clear advantage in terms of academic normativity. Although both ChatGPT and DeepSeek handle the transliteration of terms (e.g., Zhina/Qin-stan), the human–machine collaborative version—through the plural form Chinas and the italicized title The New Dictionary of General Encyclopedia—accurately captures the semantic development of historical terminology and conforms to bibliographical conventions for scholarly citation, details that are difficult for AI to grasp autonomously. Particularly noteworthy is the treatment of culture-bound terms: the human–machine collaborative version renders "Stan" consistently as Stan with an initial capital letter. It uses Turkish Stan in place of Turkestan, thereby preserving etymological transparency while avoiding the spelling confusion found in the DeepSeek version (where the term actually refers to Turkestan). This control over terminological consistency demonstrates the human translator's deep involvement in translating social-science and humanities materials. In addition, the human–machine collaborative version renders " 诸部 " as "tribes" rather than ChatGPT's "polities," which better matches the ethnographic discourse context of the late Qing and early Republican period (c. 1840s–mid-1920s).

3.3.5 Special characters

Table 5. "Oracle Bone Script"

SL	中国之“中”，甲骨文作  等、金文作  等，皆象有飘带的旗帜。(Feng et al., 2021:45)
CGT	The character zhōn 中 (middle/center) in the Chinese script appears in oracle bone inscriptions as ^ and in bronze inscriptions as ^, both graphically representing a banner or streamer-bearing flag.
DST	The character zhong (中), meaning "center" or "central," appears in oracle bone script as forms such as etc., and in bronze inscriptions as forms such as  etc., both of which depict a flag with streamers.
HMT	The Chinese character "Zhong" appeared as in shell-and-bone script and in metal script , both resembling flags with ribbons.

Analysis: A comparative review of the three renderings shows that the human–machine collaborative version achieves the best balance between academic normativity and readability. The ChatGPT version, although detailed, appears somewhat redundant—for instance, the phrase "graphically representing a banner or streamer-bearing flag" piles up modifiers. The DeepSeek version's repeated construction (e.g., "forms such as... etc.") is similarly drawn out. By contrast, the human–machine collaborative version renders " 甲骨文 " and " 金文 " with "shell-and-bone script" and "metal script," respectively, thereby preserving the visual letterforms of oracle-bone and bronze inscriptions—for example, the character " 中 "( )—and supplementing them with in-depth explanation. This kind of formulation is characteristic of translations of historical sources in the social sciences, and it reflects the human translator's control over the rhetorical pacing of academic English.

In comparison, the translation outputs produced by large language models cannot identify oracle-bone and bronze inscriptions, and merely treat them as "^." Regarding the systematic construction of terminological networks, the human–machine collaborative version renders " 飘带 " as "ribbons." Compared with ChatGPT's "streamer-bearing" and DeepSeek's "with streamers," this choice better aligns with the ceremonial connotation of the ritual system in early Chinese paleography—namely, "The qí flags had numerous bells and streamers to command the multitudes," Shuowen jiezi. In English, "ribbon" simultaneously carries decorative and ritual functions, whereas "streamer" emphasizes physical fluttering. This principled selection of conceptual equivalents stems from the human translator's deep understanding of the ritual and music civilization of the pre-Qin era.

3.3.6 Complex sentence markers

Table 6. Word Polysemy

SL	“中”还演绎为动词（读 zhòng ， 第四声），意为“对上”（如射中、猜中）、“受到”（如中计、中枪）；演绎为形容词，意指“成、好”（适中）；演为量词，有 “中等”“半”意以及 “正”“得当” 等意涵。(Feng et al., 2021:46)
CGT	“The morpheme zhōng 中 has further undergone semantic derivation into a verb (pronounced zhòng, fourth tone), signifying ‘to hit upon the target’ (e.g., shèzhòng 射中 , ‘to hit [the mark] in archery’; cāizhòng 猜中 , ‘to guess correctly’), or ‘to suffer/receive’ (e.g., zhòngjì 中计 , ‘to fall into a stratagem’; zhòngqiāng 中枪 , ‘to be struck by a firearm’); into an adjective, denoting ‘appropriate, satisfactory’ (shìzhōng 适中 , ‘moderate, well-proportioned’); and into a classifier, carrying the semantic values of ‘medium,’ ‘half,’ as well as ‘proper,’ ‘fitting,’ and ‘equitable.’”
DST	The character “ 中 ” (zhōng) is also extended to function as a verb (pronounced zhòng, fourth tone), denoting meanings such as “to hit the mark” (e.g., 射中 , shèzhòng, hitting the target; 猜中 , cāizhòng, guessing correctly) and “to suffer" or "to fall into” (e.g., 中计 , zhòngjì, falling into a trap; 中枪 , zhòngqiāng, being shot). It is further extended to serve as an adjective, signifying “proper” or “good” (as in 适中 , shìzhōng, appropriate). Additionally, it evolves into a measure word, encompassing connotations of “medium,” “half,” as well as “correct” and “appropriate.”
HMT	The word “zhong” is also used as a verb (pronounced zhòng, fourth tone), which means “squarely” (to shoot squarely or to guess correctly), “to be subjected to” (to be tricked or to be shot), and as an adjective, meaning “suitable or good” (moderate). It can also be used as a quantifier, meaning “medium”, “half”, as well as “right”, “proper”, etc.

Analysis: This translation example differs from the preceding ones in that the original content is presented in a highly complex form. Punctuation marks, Chinese pinyin, and parenthetical elements are interwoven, which inherently creates multiple inconveniences and challenges for translation—especially for large language models to accurately parse and understand the source text. A comparison of the three versions shows that the human–machine collaborative version achieves the best balance between semantic accuracy and academic communication effectiveness.

Although both the ChatGPT and DeepSeek versions appear to restore the meaning of the source text in a near word-for-word manner, the result is nevertheless unsatisfactory. The translations are overly elaborate and redundant: they not only fail to convey the original intent precisely but also impair the reading experience. For instance, when large language models process textual information within the main text such as “(e.g., shèzhòng, cāizhòng) …” or explanations like “(適 中),” they cannot streamline complexity into clarity. Instead of doing so, they translate these elements as “(e.g., shèzhòng 射中 , ‘to hit [the mark] in archery’; cāizhòng 猜中 , ‘to guess correctly’)” or similarly proceed in a way that pursues “complete coverage, exhaustiveness, and fine-grained detail” without reaching the intended sense—producing an effect that is, in fact, the opposite of what is desired.

By contrast, the human–machine collaborative version simplifies complexity into clarity. It directly supplements the information by adopting an English definitional approach. As a result, the translation is concise, clear, and immediately legible. Presenting complex semantic fields through concise sentence structures significantly enhances the academic readability of the text.

3.4 Synthesis and Comparative Conclusion

3.4.1 Shared advantages: the fundamental competence of AIGC translation

First, the conversion of basic semantics is highly reliable. Across all cases, both models do not produce major semantic mistranslations or instances of information omission, and they identify the factual information in the source text with largely accurate results. Second, awareness of cultural translation strategies is notably enhanced. When confronted with culture-specific items such as “ 王者无外 ,” both models consciously adopt a foreignization strategy characterized by “primarily transliteration, with bracketed compensation as a secondary measure,” rather than following domesticated renderings that carry overt Western-centrist coloration such as barbarian and empire. Third, performance in grammatical normativity and format stability is excellent.

3.4.2 Differentiated features: tendencies of ChatGPT and DeepSeek

ChatGPT’s translation features: It tends to employ a sentence-splitting strategy for handling long sentences. By laying out information through coordinate structures, it produces strong readability and a low reading burden. For cultural compensation, it mainly provides concentrated explanations upon the first occurrence, and then preserves transliteration in subsequent instances, which helps readers gradually acquire the relevant knowledge. Its register leans toward general academic English: sentences are regular and orderly, yet literary rhetorical effects are comparatively weak.

DeepSeek’s translation features: It favors a nested compression strategy when dealing with long sentences. As a result, it offers high information density and clear logical hierarchies. For cultural compensation, it primarily uses transliteration plus immediate bracketed annotation; whenever a core concept appears, it adds explanatory information, thereby offering greater reader-friendliness. Its register tends toward formal written academic English, using relatively archaic diction and showing a higher fit with humanities and historical texts.

3.4.3 Capability boundaries: the core space for human post-editing

A comparative analysis indicates that AIGC translations exhibit systematic limitations across the following four dimensions, which constitute the core value space for human post-editing.

i. Lack of in-depth cultural explication. There is insufficient deep understanding of diachronic semantic layering beneath concepts, institutional contexts, and the intellectual-historical trajectories involved.

ii. Insufficient explication of implicit logical relations. For long sentences, control over the implicit logical levels, the relative importance of information, and the rhythm of argumentative progression is not stable; this may lead to either “flattened elaboration” or “over-compression,” representing two extreme tendencies.

iii. Limited ability to govern overall style. There is a lack of macro-level orchestration regarding the consistency of register throughout the text, the stability of academic formality, and the bookended coherence of cultural imagery. Human–machine collaboration should not be a linear process of “machine translation plus human editing” performed once; rather, it should be an iterative conversational cycle of “prompting—generation—evaluation—feedback—iteration.”

4. Pathways to Enhancing Translators’ Digital Intelligence Literacy

The analyses of translation examples above demonstrate that AIGC exhibits systematic limita-

tions in areas such as cultural depth, the explication of logic, rhetorical re-creation, and style control. Meanwhile, the value of translators' intervention is precisely reflected in compensating for and optimizing these core shortcomings. Wang (2023), from a digital humanities perspective, provides a detailed analysis of the main problems faced by the development of translators' digital literacy, and offers targeted recommendations from multiple aspects including governmental governance, educational development, ethical construction, and scientific research. Based on this, this chapter proposes pathways for enhancing translators' digital intelligence literacy along three dimensions: technical mastery for steering, critical proofreading and editing, and ethical decision-making capability.

4.1 Technical Mastery for Steering: From "Tool Operation" to "Strategy Coordination"

Technical mastery for steering is the foundational competence required for translators to enter the human–machine collaborative field; its improvement calls for a cognitive leap from passive use to proactive design. On the one hand, translators should master prompt engineering to ensure the precise transmission of intent. They must move beyond rudimentary instructions such as "Please translate …," "Please polish …," and "If I were …" Instead, they should learn to embed translational intentions into the machine generation process in a strategic manner through techniques such as role assignment, task decomposition, and stylistic constraints. On the other hand, it is necessary to build a multi-model collaborative calling mechanism. ChatGPT and DeepSeek each have strengths in logic processing, cultural compensation, and stylistic register; translators should establish multi-model backup options and dynamically select the most suitable tools according to text types, thereby achieving complementary advantages.

4.2 Critical Proofreading and Editing: From "Error Correction" to "Value Recasting"

The deficiencies of AIGC translations are often hidden quality issues of the type "correct, but not outstanding." Therefore, the focus of proofreading and editing must move from correction to optimization, and from grammatical normativity to cultural depth and aesthetic expression. First, establish a multidimensional evaluation framework to enable precise identification of defects. Translators should internalize a six-dimensional indicator system—semantics, culture, pragmatics, logic, style, and norms—into a proofreading and editing thinking model. When evaluating AIGC output, they should quickly scan for risk points across each dimension, so as to avoid the low-standard trap of treating "grammatically correct" as "qualified." Second, strengthen cultural sensitivity and rhetorical judgment. In response to AIGC's common weaknesses such as insufficient force in cultural explication and fragile rhetorical creativity, translators need to systematically enhance their abilities in historical-context reconstruction and English rhetorical control, and to actively intervene during post-editing.

4.3 Ethical Decision-Making: From "Efficient Execution" to "Commitment to Agency"

A deep engagement by AIGC shifts translation ethics-related issues from the periphery to the center. Translation ethics refers to the system of rules, mechanisms, and value ideologies used to regulate the conduct of relevant actors and their interaction relationships throughout the entire process of conducting translation activities (Liu et al., 2025). Ethical decision-making capability is the core foundation for translators to establish the legitimacy of their profession. First, clarify the boundaries of human–machine responsibility and establish the translator's position as the subject. No matter how enhanced AIGC's generation capabilities may become, the responsibility subject for translation quality remains the translator him/herself. Translators must establish a framework of rights and obligations in which "AIGC is the proposer and

the translator is the decision-maker." Second, enhance the ability to identify cultural bias and uphold professional ethical bottom lines. Translators need to sensitively detect latent risks in AIGC outputs, such as Orientalist discourse and cultural stereotypes, and actively replace translation choices that embed value assumptions with terminology that respects the agency of cultural subjects.

5. Conclusion

This study uses A Cultural History of Thirty Key Words as the analytical corpus. Through a comparative analysis of the translations produced by ChatGPT and DeepSeek, it systematically examines the practical forms of human–machine collaborative translation in the era of AIGC, as well as the construction pathways of translators' digital intelligence literacy. AIGC demonstrates strong performance in areas such as semantic accuracy, grammatical normativity, and awareness of terminology strategies. However, it exhibits systematic limitations across four dimensions: in-depth cultural explication, the explication of implicit logic, creative rhetorical re-creation, and overall style control.

Human–machine collaboration should therefore be upgraded from a linear model of "machine translation + human revision" to a cyclical dialogic process of "prompting—generation—evaluation—feedback." Translators must take the lead in higher-order stages such as cultural calibration, logical re-framing, style setting, and creative enhancement. Translators' digital intelligence literacy constitutes a three-dimensional integrated system encompassing technical mastery for steering, critical proofreading and editing, and ethical decision-making capability. Its improvement pathway points toward a role transformation in which translators move from being "tool users" to becoming "collaborative strategy orchestrators," "quality proofreaders/editors," and "value re-constructors."

As the proverb goes, "the bigger the storm, the more expensive the fish." The more rapidly technology iterates and innovates, the more human judgment and logical thinking remain the core competitive advantages of human–machine collaboration. The enhancement of translators' digital intelligence literacy is precisely the necessary path toward rebuilding the agentive subjectivity of translation professionals in the intelligent era.

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Ethics Statement

Not applicable.

References

Anthony, P. (2014). *Exploring Translation Theories* (2nd ed.). London & New York: Routledge.

Bowker, L. (2020). *Translation technology and ethics. In K. Koskinen & N. K. Pokorn* (Eds.), The Routledge Handbook of Translation and Ethics. London & New York: Routledge.

Feng, T., & Nie, C. (2021). *A Cultural History of Thirty Key Words*. Beijing: China Social Sciences Press.

Hwang, Y., Lee, J. H., & Shin, D. (2023). What is prompt literacy? An exploratory study of language learners' development of new literacy skill using generative AI. *arXiv preprint*, 1-22. https://doi.org/10.48550/arXiv.2311.05373

Li, M., Liu, X., et al. (2026). A review of embodied intelligence imitation learning based on diffusion models. *Science China: Information Sciences*, *56*(02), 245–276.

Liu, S., Zhang, Y., & Huang, L. (2025). Translation ethics in the GenAI era: Conceptual reconfiguration, ethical changes, and choice of behavior. *Foreign Language Education*, *46*(01), 66–72. https://doi.org/10.16362/j.cnki.cn61-1023/h.2025.01.017.

Moorkens, J., & Lewis, D. (2019). Research questions and a proposal for the future governance of translation data. *Journal of Specialised Translation, (32)*, 2–25.

Shetzer, H., & Warschauer, M. (2000). *An electronic literacy approach to network-based language teaching*. In R. Kern (Ed.), Network-based Language Teaching. Cambridge: Cambridge University Press.

Siu, S. C. (2023). *ChatGPT and GPT-4 for professional translators: Exploring the potential of large language models in translation*. SSRN.

Wang, H., & Liu, S. (2025). From MTPE to AIPE: The evolution of translation modes in the GenAI era and its implications for translation education. *Shandong Foreign Language Education*, *46*(03), 111–121. https://doi.org/10.16482/j.sdwy37-1026.2025-03-011.

Wang, H., & Liu, S. (2026). "Deconstruction" and "reconstruction" of translation ethics in the generative artificial intelligence era. *Foreign Language Research, (01)*, 15–24. https://doi.org/10.16263/j.cnki.23-1071/h.2026.01.005.

Wang, H., & Liu, S. (2023). Research on translators' digital literacy from the perspective of digital humanities: Connotation, problems, and suggestions. *Theory and Practice of Foreign Language Teaching, (02)*, 70–79.

Wang, S. (2024). Reflection and reconfiguration of the translation competence system under the perspective of technological empowerment—An analysis of the "know–think–act" translation competence model of the modern translator. *English Studies, (02)*, 52–64.

Wang, Y., Qiu, J., & Hu, B. (2026). Digital intelligence literacy for generative artificial intelligence: Connotation, competency framework, and cultivation path. *Journal of Information Studies: Theory & Application*, *49*(04), 1–10. https://link.cnki.net/urlid/11.1762.G3.20260202.1443.002.

Zhu, C. (2018). Will machine translation replace human translators?—Also discussing the relationship between technology and humanities in cultivating translation talents. *Foreign Languages and Literature*, *34*(03), 101–109.

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Investigation and Analysis of the Water Environment Status of Qinghai Lake and Its Surrounding Wetlands

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Abstract

Qinghai Lake is the largest inland saltwater lake in China and also an important ecological security barrier in the northeastern Qinghai-Tibet Plateau. To reveal the characteristics of its water environment changes, this study set up sampling points in typical areas including the main lake area, estuary areas and surrounding sub-lakes of Qinghai Lake during the dry season (May) and wet season (August-September) in 2019 and 2024, respectively, to carry out synchronous collection and monitoring analysis of water quality samples, compare the differences of water environment in different periods and regions, and explore the input sources and influencing factors of nitrogen and phosphorus nutrients. The results showed that the physical and chemical conditions of the main lake area of Qinghai Lake were generally excellent, with indicators showing significant seasonal differentiation and the overall nutritional level being low. However, the total nitrogen content showed an increasing trend, and the problem of continuous input of nitrogen and phosphorus in the basin became prominent. The concentrations of nitrogen and phosphorus in the in-flowing rivers, surrounding sub-lakes and wetlands were generally higher than those in the main lake area, which were the main input sources of nitrogen and phosphorus nutrients in Qinghai Lake. The concentrations of nitrogen and phosphorus presented obvious seasonal characteristics: total phosphorus was higher in the dry season and total nitrogen was higher in the wet season, and their contents were affected by multiple factors such as surface runoff, human activities and biological activities. The results of this study can provide basic data and theoretical support for ecological protection, nitrogen and phosphorus pollution prevention and control, and scientific water resources management in the Qinghai Lake basin.

Keywords
Qinghai Lake; Surrounding wetlands; Temporal and spatial variation; Water environment

1. Introduction

Qinghai Lake is located in the northeastern part of the Qinghai-Tibet Plateau (36°32′–37°15′ N, 99°36′–100°47′ E) and is the largest inland saltwater lake in China. Zhang et al. (2020) proposed that, as a regional ecological barrier, it is not only an important stopover and breeding ground for migratory birds from Central Asia to India, an important water conservation area

and water-vapor circulation channel in western China, but also a crucial water body maintaining ecological security in the northeastern part of the Qinghai-Tibet Plateau and a natural barrier preventing the eastward spread of desertification in western China, with important ecological and strategic significance.

Affected by global climate change and regional human activities, the Qinghai Lake ecosystem is facing multiple environmental pressures. With the continuous intensification of tourism development, domestic sewage and solid waste directly pose a threat to the coastal water environment. Non-point source pollution generated by agricultural activities around the lake enters the lake area through in-flowing rivers, affecting the supply process and distribution characteristics of lake nutrients. Wang et al. (2024) found that climate warming leads to increased water temperature and evaporation, which exacerbates changes in lake hydrological rhythms and ecological processes. Deng et al. (2023) proposed that the combined effect of multiple pressures not only affects the water environment quality of the lake area and increases the risk of water eutrophication, but also adversely affects plankton, benthos and waterbird habitats, ultimately threatening the long-term stability of the health and biodiversity of the Qinghai Lake aquatic ecosystem.

In addition, Yang et al. (2025) noted that Qinghai Lake is a closed inland lake on the QinghaiTibet Plateau. Characterized by high altitude, low temperature, and a relatively simple biological community structure, its ecosystem exhibits weak selfregulation capacity and high vulnerability to degradation. Once impaired, ecological restoration is extremely difficult and cannot be achieved in the short term. Accordingly, systematic monitoring and research on the water environment of Qinghai Lake are urgently needed to reveal its spatiotemporal dynamics and provide a scientific basis for formulating targeted protection and management policies.

The lake surface of Qinghai Lake is at an altitude of 3196 m, with a lake area of about 4400 km^2 and an average water depth of 21 m, belonging to a typical plateau closed inland lake ecosystem. The lake area has a plateau continental climate with obvious regional differences in temperature: the annual average temperature in the east and south is 0.3~1.1℃, and that in the west and north is -0.8~0.6℃. The precipitation is uneven in time and space, with an annual average precipitation of 336.7 mm, mainly concentrated in May-September, and the annual evaporation is as high as 1584 mm.

The main in-flowing rivers in the lake area include the Buha River and Shaliu River, and the water body replacement cycle of Qinghai Lake is about 22 years. The total annual water supply of Qinghai Lake is 3.493 billion m^3, including 1.335 billion m^3 of runoff supply, 1.557 billion m^3 of precipitation supply and 401 million m^3 of groundwater supply; the annual evaporation is 3.93 billion m^3, with a net annual water loss of 437 million m^3.

The total area of the surrounding wetlands of Qinghai Lake is about 4952 km^2, including estuary wetlands, lakeside marshes, tidal flat wetlands and other types, which are important habitats for water birds.

The core water quality goal of Qinghai Lake is to maintain the natural state of the lake water quality, and the in-flowing rivers and surface water around the lake stably meet the Class III standard and above.

2. Materials and Methods

2.1 Study Area and Sampling Point Layout

2.1.1 Sampling time

This study investigated the water environment status of Qinghai Lake and its surrounding wetlands during the dry season (May, thawing period) and wet season (August~September) in 2019 and 2024, respectively. These two periods can reflect the key transition nodes of the lake hydrological cycle and ecological system, so as to find out the current water environment status and linkage relationship between the main and tributaries of in-flowing rivers, sub-lakes and the main lake area in the basin.

2.1.2 Survey area and sampling point layout

The survey scope includes: the main lake area of Qinghai Lake, the estuary areas of 7 main in-flowing rivers (including Buha River, Shaliu River, Quanji River, Heima River, Caiji River and Daotang River), and 4 main sub-lakes (including Jinshawan, Gahai, Erhai and Yueya Lake).

17 sampling points were set up in the main lake area: mainly in the lake center and open water areas with large water depth, less interference from human activities and relatively stable water environment, which can represent the overall water quality of the lake. 15 sampling points were set up in the estuary area: located at the confluence of main in-flowing rivers such as Buha River and Shaliu River with the lake, where the input of terrestrial nutrients is concentrated, mainly reflecting the impact of basin input on the lake water environment. 18 sampling points were set up in the surrounding wetlands: covering typical wetlands such as Erhai and Gahai, as well as lakeside marshes, tidal flat areas and nearshore tourist areas, mainly reflecting the water area characteristics of the surrounding wetlands and the interference of tourism activities on the nearshore water environment. The survey area and sampling point layout are shown in Figure 1.

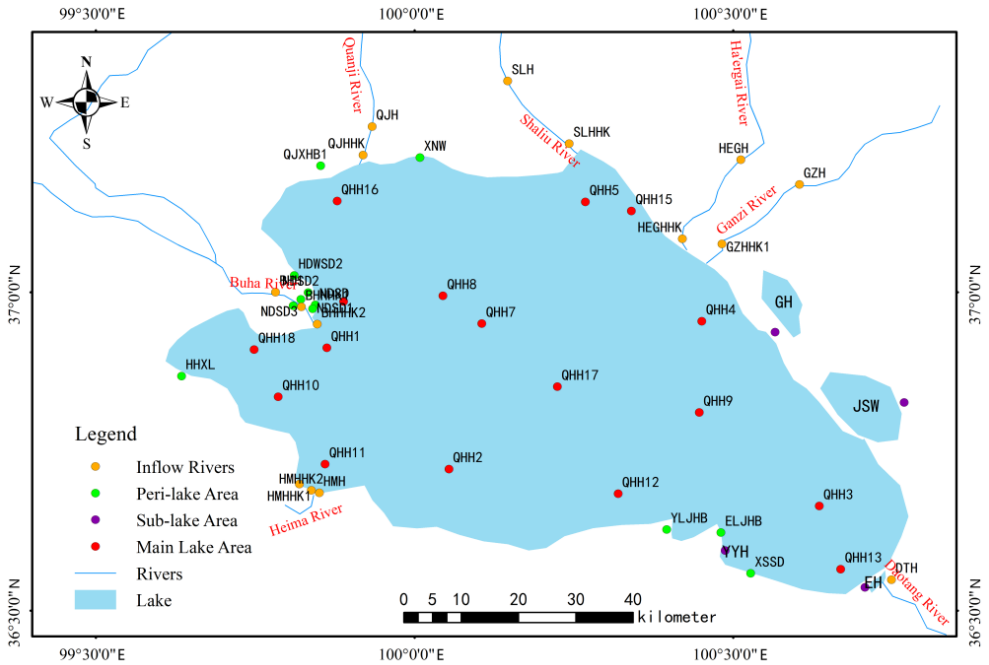

Figure 1. Layout of the survey area and sampling points

2.2 Water Environment Investigation Methods

Surface water samples were collected with reference to the Technical Specification for Surface Water Quality Monitoring (HJ 91.2—2022). Indicators such as water temperature, transparency, turbidity, dissolved oxygen, pH value, electrical conductivity and salinity were measured on site. 1 L of surface water sample was collected at each sampling point, placed in sample bottles, stored in low temperature and dark conditions, and brought back to the laboratory as soon as possible for the analysis of conventional water quality indicators such as total nitrogen, total phosphorus, ammonia nitrogen, nitrate nitrogen, dissolved phosphorus, permanganate index, chloride and chlorophyll. Preservation and transportation: the samples were stored at 4°C after sampling and sent to the laboratory for analysis within 24 hours.

Table 1. Analysis methods, detection limits and basis standards of various water quality indicators

Monitoring Indicator	Analysis Method	Detection Limit (Unit: NTU, mg/L, μS/cm)	Basis Standard
Water temperature	Thermometer method	-	SL58 - 2014
pH value	Electrode method	-	GB/T 6920
Dissolved oxygen	Electrochemical probe method	0.1	GB/T 11913
Salinity	Conductance method	0.01	GB/T 13073
Permanganate index	Acidic/alkaline method	0.5	GB/T 11892
Total nitrogen	Alkaline potassium persulfate digestion-ultraviolet spectrophotometry	0.05	GB/T 11894
Ammonia nitrogen	Nessler's reagent spectrophotometry	0.025	HJ 535
Nitrate nitrogen	Ultraviolet spectrophotometry	0.08	HJ/T 346
Total phosphorus	Ammonium molybdate spectrophotometry	0.01	GB/T 11893
Soluble phosphate	Ammonium molybdate spectrophotometry	0.01	GB/T 11893

Restricted by sampling accessibility, there were missing sampling points for the water environment indicators in the main lake area of Qinghai Lake in 2019: no samples were obtained at QHH18 in the dry season, and no samples were collected at QHH8 and QHH10 in the wet season (Figure 1); in addition, Ganzi River, Ha'ergai River and the surrounding wetlands were not included in the monitoring objects in that year. The monitoring data in 2024 were complete without missing, the names and units of each indicator were unified, and no abnormal values were found after inspection by the 3σ rule. The specific analysis methods, detection limits and basis standards are shown in Table 1.

2.3 Analysis Indicators

To compare the changes of water environment quality of Qinghai Lake in recent years and clarify the impact of surrounding wetlands and in-flowing rivers on the main lake water body, this study focused on analyzing the differences of main water environment indicators in the main lake area of Qinghai Lake between 2019 and 2024. In view of the variety of water environment indicators and complex variation characteristics, 9 key indicators such as permanganate index, total phosphorus, total nitrogen and ammonia nitrogen were selected for comparative analysis to highlight the core evolution law of water quality.

3. Survey Results and Analysis

3.1 Water Environment Characteristics of the Main Lake Area of Qinghai Lake

3.1.1 Physical and chemical indicators of the water body in the main lake area

The water quality detection results of dissolved oxygen (DO), pH, salinity and temperature in the main lake area during the wet and dry seasons in 2019 and 2024 are shown in Figure 2.

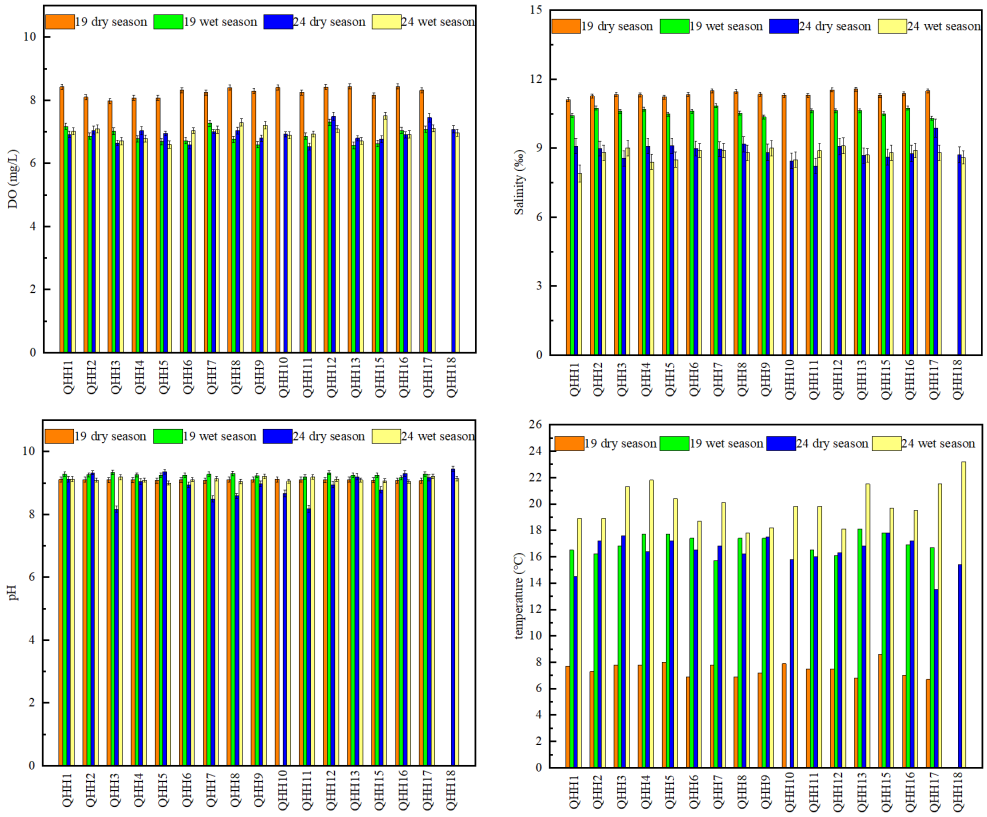

Figure 2. Water quality detection results of DO, pH, salinity and temperature in the main lake area

Dissolved Oxygen (DO)

The concentration of dissolved oxygen (DO) in Qinghai Lake was generally at a good level, all superior to the Class III limit of the surface water environmental quality standard (Figure 2). On the one hand, the overall water quality of Qinghai Lake was good, and the concentration of oxygen-consuming pollutants in the water was low (Figure 3, CODMn detection results), resulting in a high saturation of dissolved oxygen. On the other hand, the saturated dissolved oxygen concentration was negatively correlated with water temperature. The dissolved oxygen concentration at each sampling point in the dry season of 2019 exceeded 8 mg/L. Compared with the dry season of 2024 (average water temperature 16.4℃), the water temperature in the dry season of 2019 (average water temperature 7.5℃) was lower (Figure 2), leading to a higher dissolved oxygen concentration. In conclusion, the dissolved oxygen concentration in Qinghai Lake was significantly regulated by water temperature.

Salinity

The salinity in the main lake area of Qinghai Lake was generally higher in the dry season than in the wet season, and the salinity in 2019 was significantly higher than that in 2024. The salinity in the lake estuary area was slightly lower than that in the central lake area, and this spatial difference was more significant in the wet season (Figure 2). The salinity difference between dry and wet seasons was mainly controlled by the dilution effect of exogenous freshwater input in the wet season. In addition, the salinity of Qinghai Lake in 2024 decreased compared with that in 2019, reflecting that under the background of climate change in recent

years, the precipitation in some areas of the basin has increased, and the supply of main inflowing runoffs such as Buha River and Shaliu River has risen, thus producing a dilution effect on the lake water salinity.

pH

The water body in the main lake area of Qinghai Lake was weakly alkaline on the whole, with small spatial differences in pH values at each sampling point and no obvious seasonal differences between dry and wet seasons (Figure 2). Compared with ordinary freshwater bodies, the pH value of the main lake area of Qinghai Lake was slightly higher, but it was still at a low level compared with other saltwater and brackish lakes on the Qinghai-Tibet Plateau. The pH value was slightly higher in the wet season, which may be related to the enhanced photosynthesis of phytoplankton in summer.

Temperature

Water temperature is an important environmental factor affecting the changes of lake water environment. It indirectly dominates the temporal and spatial distribution characteristics of water quality indicators by regulating the physical and chemical processes of water bodies and microbial metabolic activities. Under the background of global climate change, the regional air temperature fluctuates significantly. The water temperature in the dry season of 2019 was significantly lower than that in 2024 (Figure 2), and the difference in water temperature further had an important impact on the temporal and spatial changes of key water quality indicators such as dissolved oxygen (DO) and ammonia nitrogen.

Based on the above analysis results of physical and chemical indicators of the water body, it can be seen that the physical and chemical conditions of the water body in Qinghai Lake were generally excellent, and each indicator showed significant seasonal differentiation characteristics.

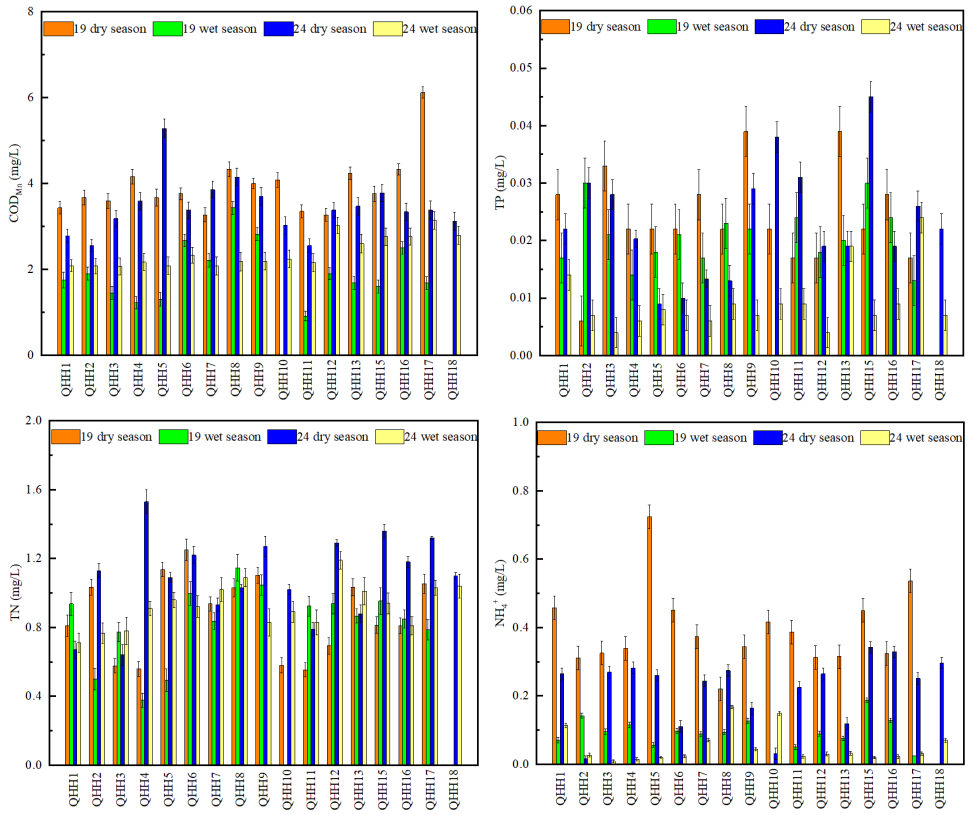

Figure 3. Detection results of CODMn, TP, TN and ammonia nitrogen in the main lake area

3.1.2 Nutritional indicators of the water body in the main lake area

Carbon, nitrogen and phosphorus are the most important nutrient elements in the ecosystem, and their concentrations determine the health status of the aquatic ecosystem. The water quality detection results of CODMn, total phosphorus (TP), total nitrogen (TN), ammonia nitrogen, etc. in the main lake area during the wet and dry seasons in 2019 and 2024 are shown in Figure 3.

Permanganate Index (CODMn)

In terms of spatial distribution, except for the QHH17 sampling point where the permanganate index once exceeded 6 mg/L, the overall water quality of Qinghai Lake was superior to the Class III limit of the Surface Water Environmental Quality Standard, and the water quality at some sampling points even reached the Class I standard in the wet season. In terms of temporal variation, compared with 2019, the permanganate index of the lake showed an overall downward trend in 2024 (Figure 3). The above results indicate that the content of oxygen-consuming pollutants in the Qinghai Lake basin is generally at a low level.

Total Phosphorus (TP)

The phosphorus content in the lake was generally at a good level. In terms of temporal variation, the total phosphorus concentration in Qinghai Lake was slightly higher in the dry season than in the wet season. The total phosphorus in the water body basically met the Class III water quality requirements of the Surface Water Environmental Quality Standard (GB 3838-2002) in the dry season, while the total phosphorus concentration was generally superior to the Class II standard in the wet season; compared with 2019, the total phosphorus concentration showed a slight increasing trend in 2024 (Figure 3).

Total Nitrogen (TN) and Ammonia Nitrogen

In terms of spatial distribution, the total nitrogen concentration at more than 50% of the sampling points in the main lake area of Qinghai Lake was greater than 1 mg/L, and the water quality was inferior to the Class III standard of the Surface Water Environmental Quality Standard. In terms of temporal variation, compared with 2019, the total nitrogen content of the lake showed an overall increasing trend in 2024, increasing in both wet and dry seasons except for individual sampling points, with a particularly significant increasing trend in the dry season (Figure 3).

There was a great difference in the ammonia nitrogen content of Qinghai Lake between dry and wet seasons, with the ammonia nitrogen concentration in the dry season significantly higher than that in the wet season (Figure 3). At lower water temperatures, the weak biological nitrification reaction may increase the ammonia nitrogen concentration in Qinghai Lake, and Qinghai Lake just experiences a process of water temperature changing from high to low from winter to summer.

Based on the above analysis results of nutritional indicators of the water body, it can be seen that the overall nutritional level of the main lake area of Qinghai Lake was low, but the nitrogen and phosphorus in the basin still showed a continuous input trend, which needs to be focused on.

In view of the generally good physical and chemical conditions of the water body in the main

lake area of Qinghai Lake, the following part focuses on analyzing the main input sources of nitrogen and phosphorus, including the nitrogen and phosphorus input characteristics of in-flowing rivers and surrounding sub-lakes in the lake area. The above areas are significantly affected by human production, living and tourism activities.

3.2 Comparison of Nitrogen and Phosphorus between the Main Lake Area and Inflow Estuaries of Qinghai Lake

The main water recharge source of Qinghai Lake is the inflowing rivers, including the Buha River, Shaliu River, Quanjing River, and Heima River. Although the Daotang River does not directly discharge into Qinghai Lake, it eventually flows into Erhai Lake, an important sub-lake of Qinghai Lake. Therefore, the Daotang River is included in the analysis as an inflowing river. The measured concentrations of total nitrogen (TN) and total phosphorus (TP) in the main lake area and river inflow estuaries during the wet and dry seasons of 2019 and 2024 are shown in Figure 4.

3.2.1 Total phosphorus (TP)

During the survey period, the total phosphorus concentration of each in-flowing river was significantly higher in the dry season than in the wet season. Among them, the total phosphorus concentration at some points of the Heima River was higher than 0.6 mg/L in the dry season of 2019, and the total phosphorus concentration of the Daotang River could also reach more than 0.5 mg/L in the dry season of 2024; while the total phosphorus concentration of in-flowing rivers decreased significantly in the wet season, and the water quality was all superior to the Class II standard of the Surface Water Environmental Quality Standard (Figure 4).

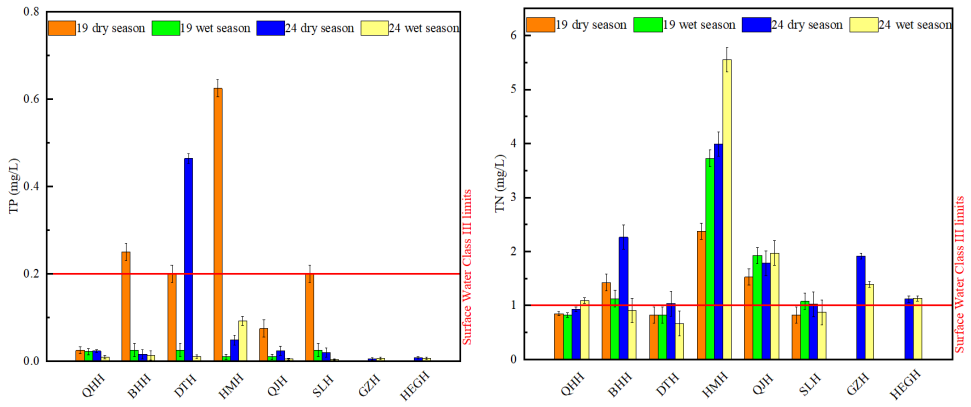

Figure 4. Comparison of total nitrogen and total phosphorus between the main lake area and inflow estuaries of Qinghai Lake

The reasons for the high total phosphorus concentration in the dry season mainly include the following three aspects: 1) The small runoff of rivers in the dry season leads to the concentration and enrichment of pollutants; 2) The grassland vegetation coverage is low in the dry season, the soil and water conservation capacity of the surface is weak, and the slope erosion effect is significant, which makes the phosphorus in the soil more likely to enter the river with runoff; 3) The sewage discharged into the river channel from the production and living activities of residents along the river is difficult to be fully diluted and diffused due to insufficient water volume in the dry season.

3.2.2 Total nitrogen (TN)

Compared with the main lake area, the total nitrogen concentration of each inflowing river

except the Daotang River was generally high, among which the Heima River had the highest concentration (Figure 4), which was particularly prominent in the wet season of 2024. The total nitrogen of the Heima River could reach more than 5 mg/L in the wet season, with the water quality being inferior Class V. In contrast, the total nitrogen concentrations of the Buha River and Shaliu River were slightly lower, but due to their larger runoff, the two rivers had a higher nitrogen input flux to Qinghai Lake.

As the two rivers with the largest inflow into Qinghai Lake, the Buha River and Shaliu River both flow through urban areas and are significantly affected by human production and living activities; at the same time, the inflow estuary sections of the two rivers both pass through grassland distribution areas, and the leaching effect of the grassland ecosystem also provides a continuous nitrogen input for the rivers.

Based on the comparison results of nitrogen and phosphorus between the main lake area and inflow estuaries, it can be seen that the nitrogen and phosphorus concentrations of the inflowing rivers of Qinghai Lake (especially the Heima River, Buha River and Shaliu River) were significantly higher than those of the main lake area, making an important contribution to the nitrogen and phosphorus input in the basin. The nitrogen and phosphorus concentrations of inflowing rivers showed obvious seasonal characteristics: the content of total phosphorus was high in the dry season and the content of total nitrogen was high in the wet season. Based on the results of this study, surface runoff scouring and urban sewage discharge are both important nitrogen and phosphorus sources of the inflowing rivers of Qinghai Lake.

3.3 Comparison of Nitrogen and Phosphorus between the Main Lake Area and Sub-lakes as well as Surrounding Wetlands of Qinghai Lake

3.3.1 Comparison of nitrogen and phosphorus between the main lake area and sub-lakes of Qinghai Lake

Several sub-lakes are distributed around Qinghai Lake. In this study, four typical sub-lakes were investigated, including Erhai Lake with freshwater recharge, Gahai Lake without freshwater recharge, Jinsha Bay (which was once separated from the main lake of Qinghai Lake but has gradually become connected again), and Yueya Lake located in the Yilangjian grassland.The measured results of total nitrogen (TN) and total phosphorus (TP) in the main lake area and river inflow estuaries during the wet and dry seasons of 2019 and 2024 are shown in Figure 5.

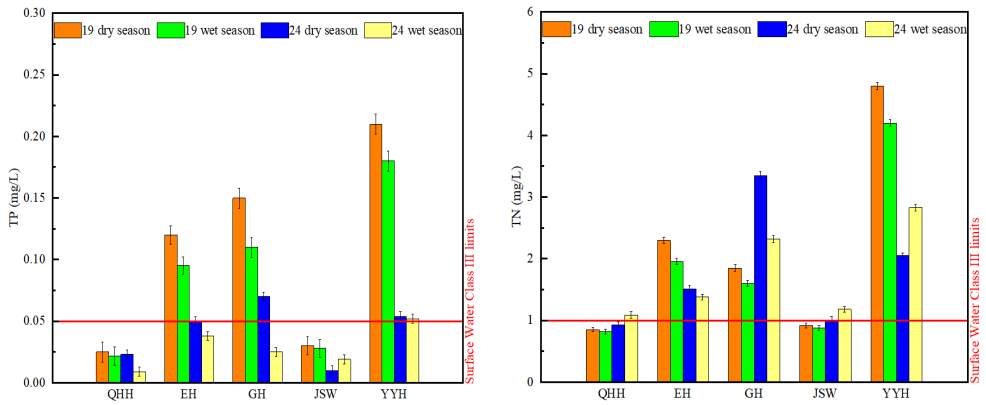

Figure 5 Comparison of total nitrogen and total phosphorus between the main lake area and sub-lakes of Qinghai Lake

Total phosphorus (TP)

In terms of total phosphorus, the total phosphorus concentrations of Gahai, Yueya Lake and Erhai were significantly higher than those of the main lake area. Among them, the total phosphorus concentration of Yueya Lake was the highest in both the dry and wet seasons of 2019 (Figure 5). The total phosphorus concentrations of Yueya Lake, Erhai and Gahai have all exceeded the Class IV or even Class V limits of the surface water environmental quality standard.

The reason is that the total phosphorus accumulation in Gahai may be caused by material accumulation due to concentration effect, while the total phosphorus in Yueya Lake is more due to the input of cattle and sheep manure around it.

Total nitrogen (TN)

Similar to the temporal and spatial variation of phosphorus, the nitrogen concentrations of these sub-lakes were basically higher than those of the main lake area of Qinghai Lake. Except for Jinshawan, the total nitrogen concentrations of the other three sub-lakes in both dry and wet seasons were much higher than those of the main lake area of Qinghai Lake, among which the total nitrogen concentration of Yueya Lake in 2019 was the highest, reaching 4~5 mg/L, far exceeding the Class V water limit of the surface water environmental quality standard (Figure 5).

3.3.2 Comparison of nitrogen and phosphorus between the main lake area and surrounding wetlands of Qinghai Lake

In 2024, the surrounding wetlands of Qinghai Lake were added as the survey objects, mainly including Xia she Wetland, Yilangjian Lakeside, Bird Island Wetland, Cormorant Island Wetland, Hadawan Wetland 2, West Ring Lake Road, Quanji Township Lakeside, Erlangjian Lakeside, Fairy Bay, Bird Island Wetland 1, 2, 3, etc. The above surrounding wetlands are significantly affected by human production, living and tourism activities, and have an obvious impact on the nitrogen and phosphorus input process in the basin.The comparison of total nitrogen and total phosphorus between the main lake area and surrounding wetlands of Qinghai Lake in 2024 is shown in Figure 6.

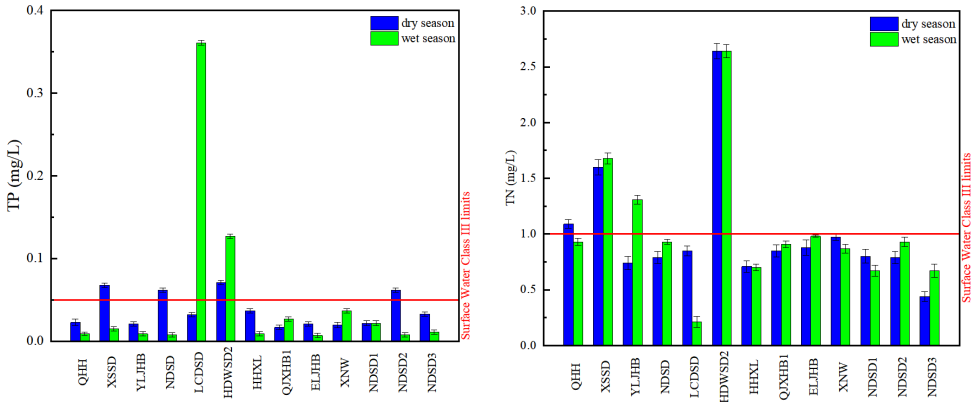

Figure 6 Comparison of total nitrogen and total phosphorus between the main lake area and surrounding wetlands of Qinghai Lake in 2024

Total phosphorus (TP)

It can be seen from Figure 6 that in terms of space, except for Yilangjian Lakeside Wetland,

the total phosphorus concentrations of other surrounding wetlands were generally higher than those of the main lake area, and the total phosphorus contents of Xia she Wetland, Bird Island Wetland, Cormorant Island Wetland, Hadawan Wetland 2 and other wetlands exceeded the Class III limit of the surface water environmental quality standard; in terms of temporal distribution, except for Cormorant Island Wetland and Hadawan Wetland, the total phosphorus concentration was generally higher in the dry season than in the wet season.

The phosphorus concentration of Cormorant Island Wetland was particularly high in the wet season, which is mainly due to the combined effect of bird habitats, exogenous input and human activities. This area is a core breeding and habitat area for water birds in Qinghai Lake. A large amount of bird manure produced by high-density birds is directly input into the water body, which is an important natural source of nitrogen and phosphorus in the wetland; at the same time, Cormorant Island is close to the inflow estuary of the Buha River, continuously receiving the input of basin non-point source nutrients carried by the river. In addition, the influence of surrounding tourism development, animal husbandry and human production and living activities further aggravates the exogenous input of nitrogen and phosphorus.

Total nitrogen (TN)

In terms of spatial distribution, the total nitrogen concentrations of Xia she Wetland and Hadawan Wetland exceeded 1 mg/L in both dry and wet seasons, higher than the Class III limit of the Surface Water Environmental Quality Standard, among which the total nitrogen concentration of Hadawan Wetland 2 even exceeded 2.5 mg/L, and the water quality reached inferior Class V. In terms of temporal variation, except for Cormorant Island Wetland, Fairy Bay and Bird Island Wetland 1, the total nitrogen concentration of most wetlands was generally higher in the wet season than in the dry season (Figure 6).

The total nitrogen concentration of the surrounding wetlands of Qinghai Lake was generally high, and was more prominent in the wet season, which was mainly affected by grassland leaching driven by strong runoff in the wet season, non-point source pollution input and nitrogen transport by inflowing rivers, superimposed with sewage discharge from surrounding human production, living and tourism activities; in addition, the slow water exchange in wetlands leads to the easy accumulation and enrichment of nitrogen in the area, which together result in a significant increase in the total nitrogen concentration of wetlands in the rainy season.

Based on the comparison results of nitrogen and phosphorus between the main lake area and surrounding wetlands, it can be seen that the nitrogen and phosphorus concentrations of Xia she Wetland, Cormorant Island Wetland and Hadawan Wetland 2 were significantly higher than those of the main lake area. The nitrogen and phosphorus concentrations of the surrounding wetlands showed similar seasonal characteristics to the inflowing rivers: the content of total phosphorus was high in the dry season and the content of total nitrogen was high in the wet season. Due to the close hydraulic connection between the surrounding wetlands and the main lake of Qinghai Lake, the continuous input of nitrogen and phosphorus from the surrounding wetlands will continuously affect the phosphorus concentration of Qinghai Lake in the future.

4. Conclusions

The physical and chemical conditions of the water body in the main lake area of Qinghai Lake are generally excellent, and each indicator shows significant seasonal differentiation characteristics. Among them, water temperature has a significant regulatory effect on indicators such as

dissolved oxygen and ammonia nitrogen. Salinity is affected by freshwater dilution in the wet season, being higher in the dry season and lower in 2024 than in 2019. On the whole, there is no water quality condition that seriously threatens the survival of aquatic organisms. The overall nutritional level of the main lake area is low, the permanganate index shows a downward trend, and the total phosphorus concentration basically meets the surface water Class III standard. However, the total nitrogen content at more than 50% of the sampling points is inferior to the Class III standard, and shows an obvious increasing trend in 2024 compared with 2019. The continuous input of nitrogen and phosphorus nutrients in the basin has become the main potential problem of the water environment of Qinghai Lake.

In-flowing rivers are the core input sources of nitrogen and phosphorus nutrients in Qinghai Lake, with their nitrogen and phosphorus concentrations significantly higher than those of the main lake area, and showing obvious temporal and spatial differences and point characteristics: the total phosphorus concentration is significantly higher in the dry season than in the wet season, affected by factors such as runoff concentration, grassland slope scouring and insufficient sewage dilution; the total nitrogen is generally high except for the Daotang River, with the Heima River having the highest concentration and reaching inferior Class V in the wet season of 2024.

The total nitrogen and total phosphorus concentrations of the surrounding sub-lakes of Qinghai Lake are generally higher than those of the main lake area. The nitrogen and phosphorus concentrations of Yueya Lake, Gahai, Erhai and other sub-lakes exceed the surface water Class IV or even Class V limits. Among them, Yueya Lake is significantly affected by the input of livestock manure around it, and Gahai has phosphorus accumulation due to concentration effect. The nutrient accumulation in sub-lakes poses a potential input pressure on the water environment of the main lake area.

The nitrogen and phosphorus concentrations of the surrounding wetlands are generally high, which are important supplementary sources of nitrogen and phosphorus input in Qinghai Lake, and show similar seasonal characteristics to the inflowing rivers: the total phosphorus is higher in the dry season than in the wet season except for Cormorant Island Wetland and Hadawan Wetland, and the total nitrogen is significantly higher in the wet season than in the dry season except for some wetlands. The nitrogen and phosphorus concentrations at points such as Xia she Wetland and Hadawan Wetland 2 exceed the standard for a long time, and the total nitrogen of Hadawan Wetland 2 even reaches inferior Class V.

On the whole, the water environment quality of the main lake area of Qinghai Lake is generally good, but the continuous input of nitrogen and phosphorus from inflowing rivers, surrounding sub-lakes and wetlands has become the main factor affecting the stability of its water environment, and the increasing trend of total nitrogen content needs to be focused on. In view of the characteristics of the plateau closed lake ecosystem of Qinghai Lake with weak self-regulation capacity and great difficulty in restoration, it is necessary to formulate differentiated prevention and control countermeasures for the key input sources and key affected areas of nitrogen and phosphorus pollution in the follow-up, strictly control the sewage discharge from human activities along the inflowing rivers, strengthen the ecological restoration and protection of surrounding wetlands and sub-lakes, and reduce the input of terrestrial nutrients, so as to maintain the long-term stability of the ecological system in the Qinghai Lake basin.

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Conflicts of Interest

The author(s) declare no conflicts of interest regarding the publication of this paper.

Ethics Statement

Not applicable.

References

Deng, D. & Deng, L. (2023). Spatial distribution characteristics and control countermeasures of nitrogen pollution load in the Qinghai Lake watershed. Environmental Impact Assessment. *45*(3): 84-93. https://doi.org/10.14068/j.ceia.2023.03.014

Fang, J. (2020). *Research on the evolution of hydrological processes and their driving mechanisms in the Qinghai Lake basin under changing environments* (Ph.D. Dissertation). Beijing Forestry University.

Hu, S., Qu, J., Zhang, L. & Zhao, M. (2023). Heavy metal content and resistance gene abundance and their correlation in the surface soil around Qinghai Lake. Environmental Science. *44*(1):336-346. https://doi.org/10.13227/j.hjkx.202202175

Li, G., Li, X. & Zhao, G.(2014). Spatiotemporal characteristics of phenology under the dynamic variation trend of grassland vegetation in the Qinghai Lake watershed. Acta Ecologica Sinica. *34*(11): 3038-3047.

Wang, M. & Wen, L. (2024). Study on water level evolution of Qinghai Lake and its influencing factors. Plateau Meteorology. (3): 561-569.

Yang, J., Jin, X., Jin, Y., et al. (2025). Changes in wetland area and its influencing factors in an alpine inland river basin. Acta Ecologica Sinica. *45*(8): 3684–3699. https://doi.org/10.20103/j.stxb.202409122208

Zhang, C., Ma, M., Zhang, S., et al. (2025). Study on main ecological problems and protection and restoration countermeasures of Qinghai Lake under the background of global warming and wetting. Qinghai Land and Resources Management. (2): 57–61.

Zhang, Y., Bai, W. & Zheng, D. (2020). *Spatial distribution characteristics and genesis analysis of lakes on the Qinghai-Tibet Plateau*. Science Press.

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