

Optimizing Translation: A Complementary Advantage Model for Human-AI Collaboration in the AI Era

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Manuscript received June 29, 2025; accepted September 3, 2025; published October 17, 2026

Abstract—The integration of artificial intelligence (AI) has significantly improved translation efficiency and scalability, but AI-generated texts often lack cultural nuance, contextual accuracy, and ethical sensitivity. This paper proposes a Complementary Advantage Model for human-AI collaboration, where AI performs repetitive tasks and humans ensure quality, cultural adaptation, and ethical oversight through a multi-stage workflow. By combining AI's speed with human creativity, the model enhances translation quality and productivity, particularly in complex fields such as legal, medical, and literary translation.

Keywords—translation, artificial intelligence (AI), Human-AI collaboration, a complementary advantage model

I. INTRODUCTION

The rapid development of artificial intelligence (AI) has transformed translation via Neural Machine Translation (NMT), Generative AI (GenAI), and large language models (LLMs). While AI tools greatly accelerate translation and improve fluency [1], they often lack deep cultural understanding, creativity, and ethical sensitivity [2].

One main driver of AI adoption is the need for productivity and scalability. Machine translation systems can process vast text volumes quickly and reduce human translators' cognitive load, enabling focus on complex nuances [3]. However, AI-generated translations frequently miss idiomatic expressions, metaphors, and humor—areas where human expertise is essential [4].

This raises the question: how can humans and AI collaborate effectively to combine their distinct strengths? [5]. Humans interpret idiomatic and culturally bound content that AI misinterprets and address issues of data privacy, bias, and accountability [6].

We propose a complementary advantage model: AI manages repetitive, large-scale translations, and human translators ensure final accuracy, cultural relevance, and adherence to ethical standards [7]. This model underscores the indispensability of human judgment in high-level decision-making and nuanced interpretation.

II. LITERATURE REVIEW

With the rise of artificial intelligence (AI) in translation, scholars have explored its impact on translation practices, quality, and professional identity. While many agree on the productivity benefits of AI-assisted systems, there is increasing concern about their limitations in handling context, culture, and ethics. Recent research has begun to shift from viewing AI as a replacement to exploring models of effective

collaboration between human translators and AI systems. This section reviews four key strands of literature: productivity and efficiency, quality and cultural challenges, evolving translator roles, and ethical considerations.

A. Productivity and Efficiency in AI-Assisted Translation

Early research in AI-assisted translation emphasized gains in speed and productivity. Guerberof Arenas (2009) showed that post-editing machine translation significantly boosts translator efficiency without greatly compromising quality [8]. AI technologies have significantly improved translation workflows, particularly in terms of processing speed and output consistency. Marconi (2020) points out that AI tools such as neural machine translation (NMT) systems are highly effective for routine and formulaic texts, such as technical manuals and corporate documentation, reducing turnaround time and costs [9]. Similarly, Liu Song (2023) notes that AI enhances productivity by automating repetitive sentence structures, making it easier for translators to focus on higher-order language functions [10]. Boulanger (2024) further observes that in localization and commercial translation, AI supports scalable multilingual delivery, enabling firms to expand their global reach efficiently [11].

B. Limitations of AI in Contextual and Cultural Translation

Despite technological advances, researchers have consistently pointed out AI's limitations in handling ambiguity, cultural context, and pragmatic meaning. Liu Song (2023) noted that while NMT excels in fluency and grammar, it often fails to preserve tone, nuance, and style, particularly in literary translation [10]. Zhao (2023) emphasized that AI systems tend to misinterpret polysemy and struggle with culturally bound expressions, which human translators can interpret more accurately [12]. These issues highlight the ongoing need for human input, especially in high-stakes or creative texts.

C. The Role of Human Translators in AI-Enhanced Workflows

As AI becomes more integrated into translation processes, the human role is evolving from creator to post-editor and ethical gatekeeper. Al-Wasy, Awashreh, and Aboeisheh (2024) proposed a collaborative model where AI handles repetitive elements and humans ensure contextual, emotional, and cultural integrity [7]. Awashreh and Aboeisheh (2025) further argued that human translators possess essential cognitive and sociolinguistic competencies that AI cannot replicate [13]. Similarly, Wang Huashu and Liu Shijie (2022)

described the translator's role as increasingly hybrid, involving post-editing, content validation, and cultural adaptation [14].

D. Ethical Challenges and Future Considerations

Ethics and bias have become central concerns in AI translation. Prates, Avelar, and Lamb (2020) warned about systemic bias embedded in training data, calling for transparent algorithmic design. Crompton, Li, and Smith (2024) stressed the need for accountability and robust data governance [7]. In practice, this means developing clear standards for bias detection and mitigation, as well as requiring human oversight in sensitive domains such as legal or medical translation. Additionally, Risku et al. (2013) and Zhou Xinghua (2024) highlighted that AI should function as an assistive tool, not a replacement, reinforcing the importance of ethical gatekeeping and informed consent in future translation workflows [3, 15].

III. AI AND HUMAN STRENGTHS IN TRANSLATION

The rapid adoption of AI technologies in translation has led to significant advancements, but it is essential to recognize that AI and human translators bring distinct strengths to the table. While AI systems excel at tasks requiring speed, scalability, and consistency, human translators are invaluable for their creative judgment, cultural sensitivity, and ethical oversight [4, 7]. This section examines the strengths of both human and AI translators, outlining how their respective abilities can complement one another in a collaborative translation environment.

A. AI Strengths in Translation

AI has demonstrated significant advantages in specific areas of translation, particularly in terms of efficiency and scalability. AI tools, such as machine translation (MT) and neural machine translation (NMT) systems, can process vast amounts of text rapidly, offering high throughput in large-scale translation projects [16, 17]. One of the most notable strengths of AI is its ability to handle repetitive tasks with remarkable speed. For example, Translation Memory (TM) systems automatically store and reuse previously translated segments, significantly reducing time spent on similar text [18]. This feature is particularly beneficial in areas like technical translations, where consistency in terminology and phrasing is essential across large volumes of text [19].

In recent years, Generative AI (GenAI) models, such as GPT-4, have expanded the capabilities of AI systems by providing contextually accurate translations with fewer data requirements compared to previous models [1]. These tools excel at fluency and syntactic correctness, making them highly effective in general text translation where high levels of creativity and cultural nuance are less critical. For instance, AI-generated translations have proven to be highly effective in domains such as scientific literature and legal documents, where clear, factual translations are prioritized over stylistic nuances [14].

Another key strength of AI in translation is its ability to scale across multiple languages and handle multilingual content. AI systems like Google Translate and DeepL support numerous languages, making them valuable for global communication and real-time translation needs [9]. These

capabilities enable companies to provide translation services to broader markets without the need for specialized human resources for each language pair.

B. Human Strengths in Translation

Despite the impressive progress of AI tools, human translators continue to offer irreplaceable strengths, particularly in tasks requiring contextual awareness, cultural sensitivity, and creativity. One of the most critical advantages of human translators is their ability to understand cultural nuances and emotional resonance, which are often absent from AI-generated translations [20]. For example, in literary translation, human translators can capture the authorial tone, metaphors, and symbolism inherent in the original text, aspects that AI tools, even with advanced language models, often misinterpret or overlook [7]. Human translators are skilled in making decisions that reflect cultural adaptations and emotional subtleties, ensuring that translations maintain the original text's essence and impact [21].

Furthermore, human creativity plays a crucial role in areas where translation involves artistic expression or stylistic variation, such as in the transcreation of marketing content or the adaptation of audio-visual translations [7]. For example, human translators often need to make decisions about how to balance localization and creativity when translating slogans or advertisements for a different cultural context. AI tools, which lack the ability to emotionally engage with the material, may produce literal translations that fail to resonate with the target audience [11].

Human translators also bring ethical considerations to the translation process, ensuring that the output is not only accurate but also culturally appropriate and non-biased. As AI systems often reflect biases inherent in their training data [22], human oversight is essential to ensure that AI-generated translations adhere to ethical standards. For example, gender bias in AI translations, where the AI incorrectly assigns gendered pronouns or overlooks gender-neutral options, requires human translators to intervene and correct such issues [23].

C. Complementary Roles of Human and AI Translators

Given their respective strengths, human and AI translators can work together in a complementary fashion to achieve better results than either could independently. AI systems excel at efficiency and consistency, particularly for technical or repetitive translations, while human translators excel at creativity, cultural understanding, and ethical decision-making [7]. In this collaborative environment, AI tools can handle the drafting or initial translation, offering a base that is quick and accurate, while human translators can focus on post-editing, ensuring the final output reflects the nuance, tone, and context that are necessary for high-quality translation [14].

Post-editing has become one of the most common forms of collaboration between human translators and AI systems. In this workflow, AI generates a rough translation that the human translator refines, addressing errors related to stylistic choices, cultural adaptation, and contextual meaning [7]. This process allows human translators to focus on quality control and creative decision-making, while AI handles the more routine aspects of translation.

The synergy between human translators and AI systems

also opens up new possibilities in multilingual and cross-cultural contexts. AI tools can quickly process and translate text into multiple languages, while human translators ensure that each version is culturally appropriate and reflects the intended tone and message [7]. The combination of human judgment and AI speed thus provides a robust framework for translating content across languages and cultures in a way that ensures both efficiency and quality.

IV. THE COMPLEMENTARY ADVANTAGE MODEL

This paper introduces the author's original Complementary Advantage Model for human-AI collaboration in translation (see Fig. 1). The model adopts a dynamic, multi-stage workflow that combines AI's efficiency with human creativity and ethical oversight. This model suggests that AI tools, when used in the right context, can augment human translators' work rather than replace them. The collaboration between the two should be symbiotic, with AI handling repetitive tasks and large-scale processing, while human translators provide insight, creativity, and cultural adaptation.

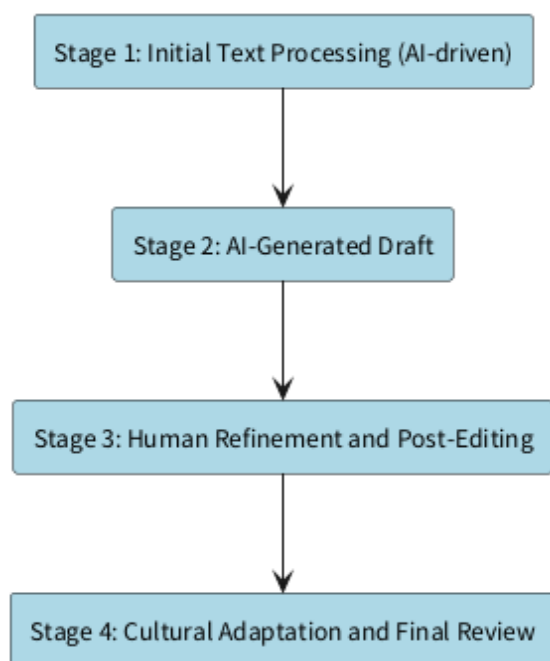


Fig. 1. Complementary advantage model: Multi-stage workflow.

A. Key Elements of the Complementary Advantage Model

Because The model is structured around a multi-stage workflow that includes various stages of AI and human interaction, ensuring both efficiency and quality control throughout the translation process. These stages can be broken down into four primary phases:

- (1) Initial Text Processing (AI-Driven)
- (2) AI-Generated Draft (AI-Driven)
- (3) Human Refinement and Post-Editing
- (4) Cultural Adaptation and Final Review

Each stage draws on the strengths of both AI and human translators to optimize the overall translation quality.

1) Stage 1: Initial Text Processing (AI-Driven)

The first stage (see Fig. 2) in the model involves AI-powered analysis of the source text. AI tools, particularly those leveraging Natural Language Processing (NLP) and

Machine Learning (ML) algorithms, parse the text to identify key linguistic features such as syntax, grammar, and semantics. In this phase, AI can extract key phrases and categorize terms based on contextual relevance. For example, AI might identify technical terminology or repeated phrases, which can later be translated with consistency.

- Strength of AI: Speed and consistency in handling large volumes of text and identifying linguistic structures.
- Strength of Humans: Human translators may review this initial text analysis for any significant misinterpretations or errors in AI's initial parsing, particularly for complex linguistic structures.

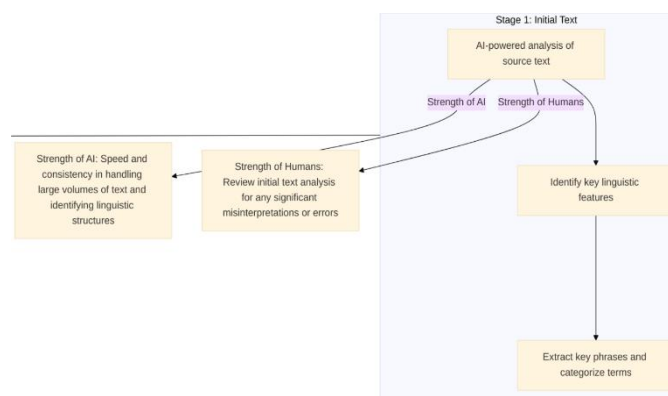


Fig. 2. Stage 1.

2) Stage 2: AI-Generated Draft (AI-Driven)

In the second stage (see Fig. 3), AI systems generate a first draft translation based on the processed source text. AI tools like Neural Machine Translation (NMT) and Generative AI (GenAI) can generate the translation at high speed, using vast databases and pretrained models to achieve high fluency and syntactic accuracy. However, these tools are limited in their ability to understand the deeper meanings of text, particularly in areas that require cultural context or domain-specific knowledge [7].

- Strength of AI: The draft is produced quickly and at scale, handling repetitive and straightforward translation tasks.
- Strength of Humans: Human translators may identify errors in translation, especially when the AI tool misinterprets ambiguous terms, colloquialisms, or slang.

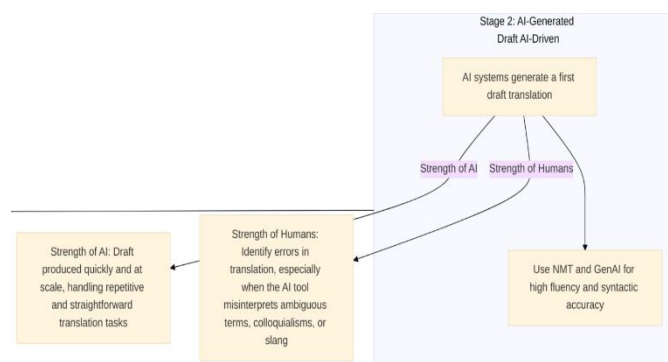


Fig. 3. Stage 2.

3) Stage 3: Human Refinement and Post-Editing

Following the AI-generated draft, human translators step in for refinement and post-editing (see Fig. 4). This is where the human strengths of creativity, critical thinking, and cultural awareness are paramount. The human translator

examines the AI-generated content to ensure that the translation is contextually accurate, stylistically appropriate, and emotionally resonant. The focus of this stage is on fine-tuning the translation, making sure that it aligns with target audience expectations, cultural norms, and the intended message of the original text.

- **Strength of Humans:** Refining the AI output by addressing cultural references, idiomatic expressions, and nuanced meanings, ensuring that the translation resonates with the target audience.
- **Strength of AI:** AI can provide suggestions and drafts for faster editing, which helps the human translator focus on more complex tasks.

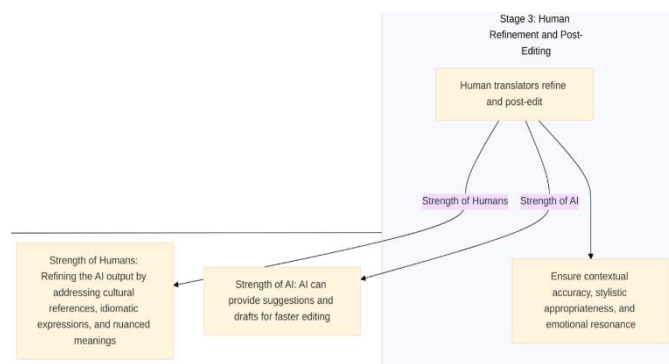


Fig. 4. Stage 3.

4) Stage 4: Cultural Adaptation and Final Review

In the final stage (see Fig. 5), the human translator ensures the translation's cultural adaptation and conducts a thorough final review of the translated content. This stage is essential for ensuring that the translation does not just accurately reflect the original text but also adheres to cultural sensitivities, localization standards, and ethical norms. The human translator also ensures that the translation maintains the tone and style appropriate for the target language and audience.

- **Strength of Humans:** Finalizing the translation with a deep understanding of the cultural, social, and ethical dimensions of language use.
- **Strength of AI:** AI can assist by performing automated quality checks for grammar, spelling, and terminology consistency.

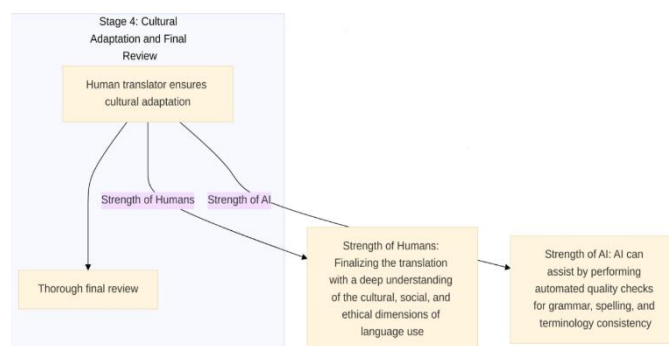


Fig. 5. Stage 4.

V. CONCLUSION

AI has transformed the translation industry by improving efficiency, scalability, and consistency. However, its full potential is realized only when paired with human strengths—creativity, cultural insight, and ethical judgment.

This paper's Complementary Advantage Model presents a collaborative framework that merges AI's speed with human nuance to ensure both quality and productivity.

In this model, AI handles tasks like draft generation and multilingual processing, while human translators refine content, ensure cultural appropriateness, and manage ethical concerns. By defining distinct roles, the model fosters synergy—optimizing AI's capabilities while preserving human insight, especially in complex fields like law, medicine, and literature. Despite its benefits, challenges remain: quality control, data privacy, ethical risks, and integrating AI into workflows. Human oversight is vital for tasks requiring contextual understanding and ethical sensitivity. Additionally, AI-related concerns like bias and data security require strong governance.

As AI becomes standard in translation, human translators must adapt—learning to collaborate with AI and focusing on high-value tasks involving creativity and critical thinking. This will reshape professional roles while emphasizing the irreplaceable human touch. Future research should refine AI's cultural and contextual understanding and explore its impact on the translation profession. Ultimately, keeping humans central to the process will ensure that translation remains accurate, ethical, and culturally sensitive.

In sum, the Complementary Advantage Model offers a clear path for effective human-AI collaboration, combining efficiency with ethical and high-quality outcomes to meet the diverse needs of global audiences.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Shixu Yuan conceptualized the study, developed the complementary advantage model. Jiaxin Lin analyzed the data, and wrote the manuscript. The authors approved the final version of the paper.

FUNDING

This work is supported by the 2026 Education and Teaching Reform Project of Northwestern Polytechnical University, entitled "Digital and Intelligent Curriculum Restructuring Driven by the International Communication for English-Chinese Translation Teaching and Practice" (Project No. JG266943).

ACKNOWLEDGMENT

The authors would like to express sincere gratitude to Northwestern Polytechnical University, Xi'an, China, for providing the academic resources and support for this research. Special thanks are also extended to the 2025 15th International Conference on Languages, Literature, and Linguistics (ICLLL) for the opportunity to engage with experts in the field. Additionally, the authors appreciate the International Journal of Languages, Literature and Linguistics (IJLLL) for its support and encouragement throughout the publication process.

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