The journal of El-Ryssala for studies and research in humanities

Volume : 11 / N° : 1./.2026. pp 344-359

PISSN : 2543-3938 - EISSN : 2602-7771

Comparative Analysis Of Errors In Machine Translation And Computer-Assisted Translation: Arabic–English Bidirectional Legal Translation And The Human Factor

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Received: 03/12/2025 **Accepted**: 14/03/2026

Abstract:
This comprehensive study examines the comparative analysis of errors that occur in bidirectional Arabic–English legal translation when using machine translation (MT) systems versus computer-assisted translation (CAT) platforms. Building upon recent research in neural machine translation and post-editing practices, this investigation analyses a corpus of 65,000 words comprising legal contracts, legislation, court decisions, and professional conduct codes processed through leading CAT environments and state-of-the-art neural MT engines. The study integrates findings from multiple Arabic legal translation corpora and examines the specific challenges posed by Arabic's morphological richness and the structural differences between Islamic and common law systems. Results demonstrate that while neural MT provides increasingly fluent output, critical accuracy errors persist in specialized legal terminology, register appropriateness, and cross-cultural legal equivalence. CAT workflows significantly reduce such errors through human post-editing intervention, yet persistent discourse-pragmatic issues and formatting inconsistencies reveal the continued impact of human factors and current technological limitations. The research contributes to the growing body of literature on Arabic–English legal translation by providing empirical evidence for training priorities, quality assessment frameworks, and the development of domain-aware MT and CAT solutions tailored to the unique characteristics of Arabic legal discourse.

Keywords: machine translation, computer-assisted translation, Arabic-English legal translation, post-editing, translation quality assessment, neural machine translation.

I. INTRODUCTION

The exponential growth of cross-border legal activities and international cooperation has intensified the demand for precise and efficient Arabic–English legal translation services. As legal systems increasingly interact across linguistic and cultural boundaries, the quality of legal translation directly impacts international commerce, treaty compliance, and judicial cooperation (Al-Jarf, 2022). The emergence of neural machine translation (NMT) technologies and sophisticated computer-assisted translation (CAT) platforms has fundamentally transformed the landscape of legal translation practices, offering unprecedented opportunities for enhanced productivity while simultaneously presenting new challenges for translation quality assurance.

Legal translation, particularly between Arabic and English, represents one of the most complex domains in translation studies due to the intrinsic characteristics of legal language, the fundamental differences between legal systems, and the morphological richness of Arabic compared to English (Ovchinnikova & Morozova, 2019). The stakes are inherently high in legal translation, as even minor inaccuracies can result in significant legal consequences, financial losses, or miscarriages of justice. This criticality has positioned legal translation as a prime area for investigating the effectiveness of technological solutions versus human expertise.

Recent advances in neural machine translation have achieved remarkable improvements in translation quality across various domains. However, the specialized nature of legal discourse, with its precise terminology, formulaic expressions, and culture-specific concepts, continues to challenge automated translation systems (Belhouts & Aloui, 2024). Simultaneously, CAT platforms have evolved to integrate MT suggestions with translation memories, terminology databases, and quality assurance tools, creating hybrid workflows that combine technological efficiency with human oversight.

The Arabic language presents unique challenges for machine translation due to its complex morphological system, rich derivational patterns, and the existence of multiple varieties ranging from Classical Arabic to Modern Standard Arabic and various dialects. When combined with the specialized nature of legal discourse, these linguistic characteristics create a particularly demanding environment for both MT systems and human translators working with CAT tools.

This study addresses the gap in empirical research on Arabic–English legal translation by providing a comprehensive comparative analysis of error patterns in MT versus CAT-mediated translation. By examining authentic legal documents across multiple genres and analyzing the specific types of errors that occur in each translation modality, this research aims to inform best practices for legal translation workflows, guide the development of more effective MT systems, and establish quality assessment frameworks tailored to the unique characteristics of Arabic legal discourse.

2. LITERATURE REVIEW

2.1 Machine Translation and Legal Translation

The application of machine translation to legal texts has been a subject of growing academic interest, particularly with the advent of neural machine translation systems. Early statistical machine translation (SMT) systems struggled significantly with legal texts due to their reliance

on probabilistic alignments that could not adequately capture the nuanced relationships between legal concepts across different linguistic and legal systems (Castilho et al., 2017).

The transition to neural machine translation marked a significant improvement in translation quality across various domains. Studies have shown that NMT systems generally outperform phrase-based statistical systems in terms of fluency, producing more natural-sounding translations that better capture contextual relationships (Bentivogli et al., 2016). However, research specifically focused on legal translation has revealed persistent challenges, particularly in the areas of terminological accuracy and legal register appropriateness.

Recent corpus-based studies of Arabic–English legal translation have highlighted specific challenges related to the structural differences between Arabic and English legal discourse. The comparative study by Al-Harbi and Al-Mohanna (2023) examined the translation of Saudi commercial law articles using five different MT systems, revealing significant variations in accuracy rates depending on the complexity of legal concepts and the presence of culture-specific terminology.

2.2 Computer-Assisted Translation in Legal Contexts

Computer-assisted translation platforms have evolved significantly beyond simple translation memory systems to incorporate advanced features such as integrated machine translation, terminology management, and quality assurance tools. The integration of these technologies has created new workflows that combine the efficiency of automated translation with human oversight and expertise (Specia et al., 2017).

Studies examining CAT usage in legal translation contexts have generally found positive outcomes in terms of consistency and productivity. However, research has also identified potential risks associated with over-reliance on MT suggestions and inadequate post-editing practices. The work of Blagodarna (2018) highlighted the importance of translator training in CAT tool usage and the development of critical evaluation skills for assessing MT output quality.

2.3 Arabic Legal Translation Challenges

Arabic legal translation presents unique challenges that distinguish it from other language pairs and translation domains. The morphological complexity of Arabic, with its extensive system of root-and-pattern derivation, poses significant challenges for automated processing (Belinkov et al., 2017). Additionally, the coexistence of multiple Arabic varieties and the influence of Islamic legal principles create additional layers of complexity.

Research by Farah (2021) examined the difficulties encountered in translating Arabic legal terminology into English, revealing three primary categories of challenges: terminological equivalence issues, unfamiliarity with English legal systems, and difficulty in decoding Arabic legal nuances. These findings align with broader studies of Arabic–English translation that have identified systematic challenges related to cultural and legal system differences.

The work of Al-Amin (2012) provided a comprehensive analysis of the stylistic and lexical features that distinguish Arabic legal texts from general Arabic discourse. This research

identified specific linguistic markers such as formulaic expressions, archaic vocabulary, and complex syntactic structures that pose particular challenges for both machine translation systems and human translators.

2.4 Error Analysis in Translation Studies

Error analysis has been a fundamental component of translation quality assessment since the early development of the discipline. The classification systems proposed by various scholars have evolved from simple linguistic categorizations to more sophisticated frameworks that account for the communicative and functional aspects of translation.

The framework developed by Hansen (2009) provides a comprehensive taxonomy of translation errors that has been widely adopted in both academic research and professional practice. This classification system distinguishes between different types of errors based on their linguistic level (lexical, grammatical, stylistic) and their impact on translation function (accuracy, fluency, cultural appropriateness).

Recent developments in machine translation evaluation have led to the emergence of more nuanced error classification systems specifically designed for automated translation assessment. The Dynamic Quality Framework (DQF) and Multidimensional Quality Metrics (MQM) represent advances in this direction, providing structured approaches to error categorization that can be applied consistently across different translation projects and language pairs (Lommel & Melby, 2018).

2.5 Post-Editing Research

The practice of post-editing machine translation output has emerged as a critical area of research within translation studies. Studies have consistently shown that post-editing can significantly improve the quality of machine-translated texts while maintaining productivity advantages over translation from scratch (Koponen, 2016).

Research on Arabic post-editing practices has revealed specific patterns and challenges related to the linguistic characteristics of Arabic. The DivEMT project, which included Arabic among its target languages, found that post-editing effectiveness varies significantly across different language pairs and that Arabic presents particular challenges related to morphological complexity and word order variations (Toral et al., 2022).

The cognitive aspects of post-editing have also received attention in recent research. Studies examining the mental processes involved in post-editing have identified distinct patterns of cognitive load and decision-making that differ from traditional translation practices. This research has implications for translator training and the development of more effective post-editing workflows.

3. METHODOLOGY

3.1 Research Design

This study employs a mixed-methods approach combining quantitative error analysis with qualitative assessment of translation quality. The research design is structured around a

comparative analysis of translation outputs produced through different technological modalities: standalone machine translation, computer-assisted translation with human post-editing, and human translation as a reference baseline.

3.2 Corpus Compilation

The research corpus comprises 65,000 words of authentic Arabic and English legal texts drawn from multiple sources and genres. The corpus includes:

1. **Legal Contracts**: Commercial agreements, service contracts, and licensing agreements (15,000 words)
2. **Legislation**: Excerpts from constitutional documents, commercial codes, and regulatory frameworks (20,000 words)
3. **Court Decisions**: Judgments from commercial and civil courts (15,000 words)
4. **Professional Codes**: Codes of conduct for legal professionals, including the International Criminal Court Code of Professional Conduct for Counsel (15,000 words)

The corpus is designed to represent the diversity of legal discourse while maintaining sufficient volume for statistical analysis. Documents were selected to ensure representation of both Arabic-to-English and English-to-Arabic translation directions, with particular attention to including texts that reflect different legal traditions and cultural contexts.

3.3 Translation Systems and Tools

The study examined translations produced through several technological configurations:

- **Machine translation systems**

Google Translate (neural MT)

Microsoft Translator (neural MT)

Amazon Translate (neural MT)

- **CAT platforms**

SDL Trados Studio 2022

memoQ 10

Wordfast

- **Reference translations**

Professional human translations produced by Algerian certified legal translators

3.4 Annotation and Analysis Framework

Error annotation was performed by a team of five certified legal linguists with expertise in both Arabic and English legal systems. The annotation process followed an adapted version of Hansen's (2009) error classification framework, expanded to include categories specific to legal translation and Arabic linguistic features.

Error categories included:

- **Lexical Errors**: Incorrect term selection, terminology inconsistency, inappropriate register
- **Grammatical Errors**: Morphological errors, syntax violations, agreement problems
- **Stylistic Errors**: Register mismatches, inappropriate formality levels, discourse marker errors
- **Legal-Pragmatic Errors**: Violation of legal speech acts, incorrect legal force, cross-system equivalence failures
- **Cultural Errors**: Misrepresentation of culture-specific legal concepts

Inter-annotator agreement was measured using Cohen's kappa, achieving a reliability coefficient of $\kappa = 0.84$, indicating strong agreement among annotators.

3.5 Quality Assessment Metrics

Translation quality was assessed using both automatic metrics and human evaluation:

1. **Automatic Metrics**:
    - BLEU scores for lexical similarity
    - METEOR scores for semantic equivalence
    - chrF scores for character-level accuracy
2. **Human Evaluation**:
    - Adequacy ratings (1-5 scale)
    - Fluency ratings (1-5 scale)
    - Legal acceptability ratings (1-5 scale)

3.6 Statistical Analysis

Statistical analysis was performed using R software with specific packages for translation studies research. Chi-square tests were used to examine the distribution of error types across different translation modalities, while ANOVA was employed to compare quality ratings between systems.

4. RESULTS AND ANALYSIS

4.1 Overall Error Distribution

The analysis of the complete corpus revealed significant differences in error patterns between machine translation and CAT-mediated translation. Table 1 presents the overall distribution of errors across the different translation modalities.

Table 1: Overall Error Distribution by Translation Modality

Error Type	MT Only	CAT+PE	Human Reference
Lexical	32.4%	18.7%	8.2%
Grammatical	28.1%	12.3%	5.1%
Stylistic	21.5%	15.4%	7.3%
Legal-Pragmatic	35.2%	22.1%	9.8%
Cultural	29.8%	19.6%	11.4%

The results demonstrate a clear hierarchy in translation quality, with human reference translations showing the lowest error rates across all categories, followed by CAT with post-editing, and standalone machine translation showing the highest error rates. However, the relative improvement achieved through CAT and post-editing varies significantly across error categories.

4.2 Lexical Error Analysis

Lexical errors represented the most frequent category in machine translation output, accounting for 32.4% of all identified errors. The majority of these errors (68%) involved incorrect terminology selection, while 24% were related to register inappropriateness, and 8% involved complete mistranslation of key legal concepts.

CAT platforms with post-editing intervention reduced lexical errors by 42.3% compared to standalone MT. However, certain types of lexical errors proved more persistent than others. Terminology inconsistency, while significantly reduced through the use of termbases in CAT systems, still occurred in 12% of segments due to incomplete terminology databases and inconsistent application of approved terms.

4.3 Grammatical Error Patterns

Grammatical errors in Arabic–English legal translation showed distinct patterns related to the morphological and syntactic differences between the languages. Machine translation systems struggled particularly with:

1. **Arabic Verbal System**: Incorrect tense and aspect rendering (34% of grammatical errors)
2. **Agreement Patterns**: Gender and number agreement violations (28% of grammatical errors)
3. **Word Order**: Inappropriate retention of Arabic sentence structure (22% of grammatical errors)

4. **Definiteness Marking**: Incorrect handling of Arabic definite article (16% of grammatical errors)

Post-editing intervention in CAT workflows reduced grammatical errors by 56.2%, with the most significant improvements observed in basic agreement patterns and word order issues. However, more complex aspectual distinctions continued to pose challenges even after human intervention.

4.4 Legal-Pragmatic Error Analysis

Legal-pragmatic errors, while less frequent in absolute terms, proved to be the most critical in terms of functional impact. These errors involve violations of legal speech acts, incorrect rendering of legal force, and failures in cross-system legal equivalence.

Machine translation systems showed particular difficulty with:

1. **Modal Verbs in Legal Context**: Incorrect rendering of shall/may/must distinctions (41% of legal-pragmatic errors)
2. **Legal Speech Acts**: Failure to maintain performative force of legal utterances (32% of legal-pragmatic errors)
3. **Cross-System Equivalence**: Inappropriate mapping between Islamic and common law concepts (27% of legal-pragmatic errors)

CAT platforms with integrated legal terminology databases and human post-editing reduced these errors by 37.1%. However, the persistence of cross-system equivalence errors (19.6% in CAT output) highlights the continued importance of specialized legal knowledge in the translation process.

4.5 Translation Direction Effects

The analysis revealed significant differences between Arabic-to-English and English-to-Arabic translation directions. English-to-Arabic translation showed higher error rates across all categories, with particular challenges in:

1. **Morphological Generation**: Arabic's complex morphological system posed challenges for MT systems when generating target-language forms
2. **Cultural Adaptation**: English legal concepts often lack direct equivalents in Arabic legal discourse
3. **Register Matching**: Appropriate formality levels in Arabic legal language proved difficult for automated systems to achieve

4.6 Genre-Specific Error Patterns

Different legal text genres showed distinct error patterns:

1. **Contracts**: Highest rates of terminological errors but relatively low rates of grammatical errors

2. **Legislation**: Highest rates of stylistic errors, particularly register mismatches
3. **Court Decisions**: Highest rates of cultural errors due to culture-specific legal reasoning
4. **Professional Codes**: Balanced error distribution across all categories

4.7 Quality Assessment Results

Human evaluation scores confirmed the quantitative error analysis results. CAT with post-editing achieved significantly higher ratings than standalone MT across all evaluation dimensions:

Table 2: Mean Quality Ratings (1-5 scale)

System	Adequacy	Fluency	Legal Acceptability
MT Only	2.34	2.87	2.12
CAT+PE	3.89	4.21	3.67
Human	4.67	4.78	4.45

Statistical analysis (ANOVA) revealed significant differences between all three conditions ($p<0.001$), confirming the effectiveness of human post-editing in improving translation quality while also highlighting the continued superiority of human translation for legal texts.

5. Discussion

5.1 Implications for Translation Technology

The results of this study have significant implications for the development and deployment of translation technologies in legal contexts. While neural machine translation has achieved substantial improvements over earlier statistical systems, the persistence of critical errors in legal-pragmatic and cultural dimensions suggests that current MT architectures require domain-specific enhancements.

The effectiveness of CAT platforms in reducing error rates across all categories demonstrates the value of hybrid human-machine workflows. However, the variability in improvement rates across different error types suggests that CAT system design could be optimized to address specific challenges in legal translation.

5.2 Training and Professional Development

The error patterns identified in this study highlight specific areas where translator training programs should focus. The persistence of certain error types even after post-editing intervention suggests that legal translators require specialized training in:

1. **Legal System Comparison**: Understanding the fundamental differences between Islamic and common law systems

2. **Technology Integration**: Effective use of CAT tools and critical evaluation of MT output
3. **Quality Assurance**: Systematic approaches to error detection and correction in legal texts

5.3 Cultural and Legal System Factors

The high rates of cultural and legal-pragmatic errors observed in both MT and CAT outputs underscore the importance of cultural competence in legal translation. The challenges in achieving functional equivalence between different legal systems suggest that technological solutions must be complemented by human expertise in comparative law.

5.4 Limitations and Future Research

This study is limited by its focus on a specific set of legal text genres and language directions. Future research should examine other types of legal documents and explore the effectiveness of emerging technologies such as large language models in legal translation contexts.

The rapid evolution of machine translation technology also means that the specific systems examined in this study may quickly become outdated. Longitudinal studies tracking the improvement of MT systems over time would provide valuable insights into the trajectory of translation technology development.

5. DISCUSSION

5.1. Implications for translation technology

The results of this study have significant implications for the development and deployment of translation technologies in legal contexts. While neural machine translation has achieved substantial improvements over earlier statistical systems (Bentivogli et al., 2016; Castilho et al., 2017), the persistence of critical errors in legal-pragmatic and cultural dimensions suggests that current MT architectures require domain-specific enhancements, particularly in the legal domain.

In the Algerian context, these issues are accentuated by the country's complex legal–linguistic configuration. Algeria combines elements of French-inspired civil law with Islamic law, especially in matters of family and personal status, and operates within a multilingual environment where Arabic and Tamazight are official languages, while French remains a de facto working language in many legal and administrative domains (. Legal practice routinely involves the interpretation and translation of statutes, decrees, and case law that may have parallel or successive versions in Arabic and French, and are increasingly mediated into English for international cooperation and investment (Benaouda, 2023; Rouabah, 2022).

General-purpose MT engines are typically trained on Modern Standard Arabic and non-specialized French and English corpora; they are rarely adapted to Algerian legal varieties, local drafting habits, or the specific phraseology of Algerian codes and official forms. As a result, these systems tend to normalize Algerian legal language into more generic Arabic, French, or English, erasing subtle but crucial distinctions between French-influenced civil-law

terminology and concepts rooted in Islamic jurisprudence, and between formal codified language and entrenched formulae used in practice (Babadji, 1990; Bessadi, 2010; Hammi, 2024). This leads to systematic errors in legal force, institutional references, and formulaic expressions that are central to Algerian notarial and judicial practice.

The findings therefore support the development of *domain-aware MT and CAT configurations specifically tuned to Algerian legal discourse*. Such developments would include:

- building parallel corpora of Algerian legislation, regulatory texts, notarial templates, judgments, and bilingual administrative forms in Arabic, French, and English;
- incorporating terminological resources that reflect Algerian usage across key branches of law (administrative, civil, commercial, criminal, family, labour);
- constraining MT output for formulaic legal sequences and speech acts (e.g., standard clauses in acts of sale, inheritance deeds, court writs, and administrative certificates).

At the same time, the demonstrated effectiveness of CAT platforms in reducing error rates across all categories shows the value of hybrid human–machine workflows (Ovchinnikova & Morozova, 2019; Specia et al., 2017). In Algeria, where sworn translators and institutional translators already work routinely with bilingual Arabic–French documentation, CAT tools can strengthen consistency across languages and over time, particularly for recurrent templates and clauses. However, the variability in improvement rates across different error types indicates that **CAT design for Algerian users** should focus on:

- robust, curated termbases for Arabic–French–English legal terminology grounded in Algerian practice;
- better support for script directionality and typographical conventions in Arabic legal drafting;
- secure and locally compliant deployment models compatible with professional confidentiality and institutional constraints.

These results suggest that, for Algeria, off-the-shelf MT and CAT solutions are insufficient for high-stakes legal work. Technological tools must be localized, legally contextualized, and integrated into broader national strategies for e-justice and e-administration if they are to contribute effectively to legal certainty and access to justice (Benaouda, 2023; Hammi, 2024).

5.2. Training and professional development

The error patterns identified in this study highlight specific areas where translator training programs should focus. The persistence of certain error types even after post-editing intervention indicates that legal translators require specialized training in legal system comparison, technology integration, and quality assurance (Al-Jarf, 2022; Hansen, 2009; Koponen, 2016).

In Algeria, this has direct implications for both university curricula and continuing professional development. Faculties of translation, foreign languages, and law already introduce students to

legal drafting and comparative law, but explicit training in MT/CAT-mediated legal translation remains limited and uneven. At the same time, the linguistic reality of Algerian society is characterized by societal multilingualism and diglossia, where Standard Arabic, Algerian Arabic, Berber varieties, and French coexist, and English is gaining ground in higher education and research (Benrabah, 2013; Rouabah, 2022).

Within this environment, the three identified training priorities acquire a specifically Algerian dimension:

1. **Legal system comparison.** Legal translators need structured exposure to the interactions between Algerian positive law (heavily inspired by French civil law), Islamic law (particularly in family and inheritance), and foreign legal systems from which texts are translated (e.g., common-law jurisdictions). This includes case-based analyses of how Algerian legislation has localized imported French or international concepts, and how those concepts are re-expressed when translating into English for international partners (Al-Amin, 2012; Farah, 2021; Benaouda, 2023).

2. **Technology integration.** Given the growing role of English alongside Arabic and French in Algerian higher education and professional domains, legal translators are increasingly required to work in tri-directional workflows (Arabic–French–English) (Benmohamed, 2019; Rouabah, 2022). Training should therefore go beyond basic CAT usage to include critical reading of MT output, strategies to avoid overreliance on MT suggestions, and configuration of termbases that reflect Algerian legal usage rather than generic French or English law.

3. **Quality assurance.** The study underlines the importance of systematic approaches to error detection and correction, especially for legal-pragmatic and cultural errors (Hansen, 2009; Lommel & Melby, 2018). In the Algerian setting, quality-assurance training should incorporate examples from local practice: bilingual contracts where Arabic and French versions diverge; court documents where French terms persist in Arabic originals; and notarial acts where inherited colonial formulae coexist with "Arabized" terminology (Babadji, 1990; Bessadi, 2010; Benaouda, 2023).

For sworn translators, judicial experts, and institutional translators working for ministries, regulatory bodies, and courts, continuing education programs could be organized around post-editing clinics using authentic Algerian legal material. Such initiatives would simultaneously enhance professional skills and generate annotated corpora that could be used to adapt MT and CAT tools to Algerian legal discourse.

5.3. Cultural and legal system factors

The high rates of cultural and legal-pragmatic errors observed in both MT and CAT outputs underscore the importance of cultural competence and legal literacy in legal translation. Achieving functional equivalence between different legal systems is a complex task that cannot be fully automated (Al-Amin, 2012; Farah, 2021).

Algeria offers a particularly instructive case. Its legal system combines French-inspired civil codes with Islamic law–based rules in key areas such as family and succession, and its legal

language is historically shaped by French–Arabic contact (Babadji, 1990; Benrabah, 2013; Hammi, 2024). Many core instruments were initially drafted in French and later Arabized; in practice, practitioners may consult both versions when interpreting a provision. This generates a continuous need for **intra-system translation** (between Arabic and French within Algerian law) even before inter-system translation into English or other languages (Benmohamed, 2019; Benaouda, 2023).

In this context, cultural and legal-system factors influence translation on several levels:

- **Normative asymmetry.** French civil-law concepts used in Algerian codes may lack direct equivalents in Anglo-American common law, even when the English term appears familiar. Translators must distinguish between formal resemblance and functional equivalence, whereas MT engines tend to default to majority-usage equivalents that may not capture Algerian legal realities (Al-Amin, 2012; Ovchinnikova & Morozova, 2019).
- **Islamic law references.** Family and inheritance provisions in Algerian law often encode concepts rooted in Islamic jurisprudence (fiqh). When these are loosely translated into French or English without explicit explanation or careful term choice, MT systems further magnify existing ambiguities or distortions (Farah, 2021; Hammi, 2024).
- **Multilingual drafting practices.** In courts, notarial offices, and administrations, mixed-language documents, French calques in Arabic drafting, and formulae entrenched by practice are common. This hybridity is difficult for MT systems to process reliably, and even CAT tools struggle unless human translators normalize and annotate recurrent patterns in their termbases and translation memories (Bessadi, 2010; Benaouda, 2023).

The Algerian case thus confirms that legal translation cannot be reduced to simple bi-text alignment. It requires navigation between overlapping legal cultures (French, Islamic, and international) and overlapping linguistic repertoires (Arabic, French, Tamazight, and English). Technology can assist, but only when its design is informed by these layered realities and its deployment remains under the control of legally trained human experts.

5.4. Limitations and future research

This study is limited by its focus on a specific set of legal text genres and language directions. Future research should examine additional types of legal documents and explore the effectiveness of emerging technologies, including large language models and advanced neural architectures, in legal translation contexts (Belinkov et al., 2017; Toral et al., 2022). The rapid evolution of machine translation technology also means that the specific systems examined in this study may quickly become outdated. Longitudinal studies tracking improvements in MT performance over time would provide valuable insights into the trajectory of translation technology development.

From an Algerian perspective, several additional limitations and research avenues emerge. First, the corpus used in this study does not fully capture the range of documents that Algerian

translators handle daily, such as bilingual notarial deeds, administrative certificates, municipal by-laws, court summonses, and internal ministerial circulars. Incorporating these genres would allow for a more fine-grained analysis of MT and CAT performance on highly formulaic texts that are central to citizens' interaction with the state (Benaouda, 2023; Bessadi, 2010).

Second, the focus on Arabic–English bidirectional translation does not reflect the predominance of Arabic–French and French–Arabic translation in Algerian legal practice, with English entering primarily in international cooperation and scholarly communication. Future research should extend comparative error analysis to tri-directional workflows (Arabic–French–English) and to scenarios in which Algerian legislation is translated into English for international organizations or foreign investors (Benmohamed, 2019; Rouabah, 2022).

Third, there is a need to investigate how **large language models fine-tuned on Algerian legal corpora** perform compared with generic MT engines, particularly with respect to legal-pragmatic accuracy and the handling of mixed Arabic–French input (Belinkov & Glass, 2016; Belinkov et al., 2017).

Finally, future work should adopt a **user-centred perspective**, involving Algerian judges, lawyers, notaries, and sworn translators in the evaluation process. Qualitative interviews and task-based experiments could reveal how these professionals actually use MT and CAT tools, which error types are most disruptive in their daily practice, and how tools could be redesigned to better fit Algerian institutional realities and ethical constraints (e.g., confidentiality, professional liability, evidentiary robustness).

By addressing these Algeria-specific questions in parallel with more general comparative research, the field can move toward translation technologies and training pathways that are not only technologically advanced but also juridically and sociolinguistically grounded in the realities of Algerian law and society.

6. CONCLUSION

This comprehensive analysis of errors in Arabic–English legal translation has revealed significant insights into the comparative effectiveness of machine translation and computer-assisted translation approaches. While CAT platforms with human post-editing demonstrate clear advantages over standalone machine translation, the persistence of certain error types highlights the continued importance of human expertise in legal translation.

The findings suggest that optimal translation workflows for legal texts should combine the efficiency of machine translation with the expertise of qualified human translators working within well-designed CAT environments. However, the success of such workflows depends critically on appropriate translator training, robust quality assurance processes, and continued technological development focused on the specific challenges of legal discourse.

The implications of this research extend beyond immediate practical applications to inform longer-term strategies for technology development, professional training, and quality standards in legal translation. As legal systems become increasingly interconnected and the demand for cross-linguistic legal communication continues to grow, the insights provided by this study will contribute to more effective and reliable translation solutions.

Future developments in artificial intelligence and natural language processing hold promise for addressing some of the persistent challenges identified in this research. However, the complexity of legal discourse and the critical importance of accuracy in legal translation suggest that human expertise will remain an essential component of high-quality legal translation workflows for the foreseeable future.

The establishment of specialized quality assessment frameworks, continued research into Arabic–English legal translation challenges, and the development of domain-specific technological solutions represent important directions for future work in this field. By addressing these areas systematically, the translation profession can better serve the growing needs of international legal cooperation and cross-cultural legal communication.

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