| **RESEARCH ARTICLE**

Challenges of Post-Editing in English to Arabic Machine Translation of Technical Texts: A Study of Technological and Linguistic Barriers

Haifa Mohammad Nassar

Assistant Professor, Hajjah University, Faculty of Education and Humanities, Hajjah, Yemen
Corresponding Author: Haifa Mohammad Nassar, **E-mail**: haifaaama@gmail.com

| **ABSTRACT**

The increasing reliance on machine translation (MT) for English-to-Arabic technical texts presents significant linguistic and technological challenges, necessitating extensive human post-editing. This study examines these challenges by analyzing machine-translated technical texts and assessing the post-editing process undertaken by professional translators. Despite advancements in neural machine translation, English-Arabic translation remains problematic due to syntactic, morphological, and terminological discrepancies between the two languages. The study employs House's (1997) Translation Quality Assessment (TQA) Model to evaluate machine translation quality and the impact of post-editing interventions. Methodologically, ten technical texts were selected from car and hair dryer manuals and translated using Google Translate. Two professional translators, each holding a PhD in translation, post-edited these texts in a two-stage process, producing a single collaboratively refined version. Semi-structured interviews were then conducted to explore the translators' experiences, the challenges they faced, and their perspectives on the effectiveness of MT tools. The analysis of the interviews revealed key technological and linguistic barriers, including inconsistent terminology, unnatural sentence structures, and difficulties in maintaining semantic and pragmatic accuracy. The findings highlight that MT tools struggle with context-sensitive technical terms, resulting in inaccuracies that demand significant human intervention. Additionally, issues such as word order mismatches, poor handling of Arabic morphology, and ineffective recognition of formal registers contribute to the post-editing workload. The study recommends improvements in MT systems, including enhanced AI-driven context recognition, customizable glossaries, and adaptive learning mechanisms to refine MT accuracy over time. By addressing these gaps, MT tools can better integrate into professional translation workflows, reducing post-editing efforts while improving the quality of English-to-Arabic technical translations.

| **KEYWORDS**

Machine Translation, Post-Editing, English-to-Arabic Translation, Technical Texts and Translation Quality Assessment

| **ARTICLE INFORMATION**

1.   Introduction

In the rapidly developing field of machine translation (MT), the passage of transition from initial automatic translations toward highly developed texts of a professional standard involves a critical phase known as post-editing (Indarti, 2024; Vieira, 2019). This involves the correction and improvement of machine-generated output at the hands of human translators and the assurance of the accuracy, culture appropriateness, and comprehensibility of the translation (de Souza, 2024). The present study seeks to identify the particularities and challenges of the technical translations' post-editing of the language pair of English-Arabic that has distinct linguistic and structural features.

English and Arabic fall into two distinct language families with the latter identified as a Semitic language and the former a Germanic language (Kamusella, 2017). This critical distinction poses a lot of challenges in the field of machine translation and specifically the

translation of technical content from the English language into the Arabic language (Zakraoui et al., 2021). The challenges transcend the linguistic differences—syntax, morphology, and semantics—into the technical issues of the capabilities and limitations of modern-day machine translation systems specifically designed for each respective language (Alkhatib&Shaalan,2018).

The relevance of the current study is compounded by the need for the highly technical translations of specialized documents that has been necessitated mainly by globalization and the onset of the information age of the internet and technology (Akpaca et al., 2020). Arabic language has a large population of speakers of over 300 million and poses a large and widening opportunity of the digital world and technical services that need translation. Nevertheless, not with standing the demand that exists, technical translation of the content of specialized documents often does not live up to set standards and therefore needs a lot of human intervention (Alanazi, 2019).

This study seeks to examine the particular technology and language barriers that affect the effectiveness and output of technical translations of technical texts in English into the Arabic language. Through the identification of such barriers, the study looks to offer findings that may help enhance the methods of machine translation and streamline the post-editing process in an effort to lower the associated times and costs of providing good-quality translations of technical content in the Arabic language.

This study offers valuable contributions to the field of translation studies and practical guidance to translators, language services companies, and machine translation technology developers. The ultimate goal of this study is the improvement of the use of machine translation technologies in translation processes at the professional level with the expectation of improving the quality of correct and culturally relevant translations of technical texts in the Arabic language.

2. Questions of the Study

1. What specific technological limitations of current machine translation systems contribute most to the post-editing workload when translating technical texts from English to Arabic?
2. How do linguistic differences between English and Arabic affect the accuracy and reliability of machine translation outputs for technical texts?
3. What improvements in machine translation technology could significantly reduce the time and effort required for post-editing English to Arabic translations of technical texts?

3. Literature Review

3.1 Overview of Machine Translation Challenges for Technical Texts

Machine translation (MT) from English to Arabic presents unique challenges, particularly when dealing with technical texts. Foundational insights by Churchill (2014) and Besold et al. (2021) discuss the technological underpinnings of MT systems, especially focusing on statistical and neural network approaches. Studies on Machine Translation (e.g. Sun, 2010; Nieminen, 2018) underline the general challenges of MT, such as managing syntactic and semantic divergences, which are intensified by the specialized vocabulary and structured formats inherent in technical documentation.

3.2 Technological Barriers in MT for Technical Texts

The specific technological issues involved in MT in translating technical content are well documented. Alkhatib and Shaalan (2018) refer to the difficulty presented by the morphological complexity of Arabic compared to the simplicity of English, which leads to gross translation errors, especially with technical terminology. Issa (2016) discusses the effect of Arabic's intricate morphological structures on machine translation, commenting on the requirement for algorithms with the ability to handle complex verb and noun forms typical in specialized language. Tambouratzis et al. (2017)'s application of an attention mechanism is what accounts for the long-distance dependencies typical in technical descriptions and procedures that play a key role in ensuring technical information integrity during translation.

3.3 Linguistic Differences and Post-Editing Effort in Technical Translations

Koponen (2016a) considers the effectiveness of post-editing and concludes that linguistic variety among languages increases the duration of the post-editing process substantially, particularly in technical translations that call for a great degree of accuracy. Koponen (2016b) looks at the post-editing of the Arabic language and notes that the typical patterns of errors include word-for-word translations that do not properly reflect the suitable technical jargon and field language.

3.4 Enhancements in MT for Arabic Technical Texts

As AI and machine learning have developed, the endeavours to enhance MT for Arabic have accelerated. Marie-Sainte (2018) discusses utilizing advanced machine learning algorithms tailored to the linguistic composition of Arabic. Their paper suggests the integration of contextual understanding ability into NMT systems to significantly reduce ambiguity errors, which are particularly problematic in technical translations where precise meaning could be critical.

Literature (Ashqar, 2013; Ali &Sayyiyed Al-Rushaidi, 2017) confirms the complexity of English-to-Arabic technical text translation problems rooted in both linguistic and technological aspects. Although recent innovations in NMT and AI have started addressing such issues, a significant gap exists, especially in post-editing technical text workload. This study continues from previous studies, targeting particularly the technological and linguistic issues which affect the productivity of post-editing English-to-Arabic translations of technical texts. Through the identification of specific enhancements, this research proposes to improve not only the velocity but also the quality of such translation processes, thereby making significant contributions to fine-tuning machine translation for technical texts.

4. Research Methodology

This section provides the methodology of the study as follows:

4.1 Study Design

The present study adopts a qualitative approach to provide an in-depth analysis of the complexity of post-editing of machine translation of technical texts from English to Arabic. Given the complexity of this research, which demands sensitivity to machine translation and human translators' experiences, qualitative research is especially appropriate. It enables thorough investigation of technological and linguistic limitations affecting the quality of translation, and thus provides denser contextual data related to the human factors that affect post-editing.

4.2 Data Collection and Sampling

The data used in the present study includes ten technical manuals drawn from two different English manuals, namely an automobile and a hair dryer. The two manuals were chosen through purposive sampling and translated into Arabic with the help of Google Translate. The machine-generated translations were subsequently subject to post-editing done by two expert translators with a PhD in translation and a lot of experience in the post-editing of machine translation technical texts. The translation that had been done by the first translator underwent additional review and revision at the hands of the second translator with the final output refined into a unified collaborative version. Following this process, the two translators underwent interviews carried out by the researcher. The interviews examined the experience of the two translators and the challenges they had during the post-editing process and also their views about the effectiveness of the use of machine translation tools within technical translation.

4.3 Methods of Data Analysis

In order to scrutinize the collected data, the study uses thematic analysis of the interview transcripts to identify overarching themes of the issues of post-editing that the translators experience. Furthermore, it uses content analysis to examine the unique categories of errors that appear within the machine translation output and assess the changes that take place during the post-editing process. This framework of methods provides qualitative insight into the intricacies that lie within the post-editing process.

4.4 Theoretical Framework

The theoretical framework of this study of the challenges of post-editing machine-generated technical translations of technical texts from English into Arabic stems from House's (1997) Model of Translation Quality Assessment. This model proposes a holistic framework for assessing translation quality that considers the source and the target language and also imposes a hierarchy of the two languages. The model proposes two critical parameters—pragmatic and semantic equivalence—that allow a comprehensive analytical framework and thus assure the technical translations' quality.

Criteria of the TQA Model

1. Pragmatic Equivalence: This criterion examines whether the translation achieves the same purpose as the original text. In the context of technical texts, this involves ensuring that the instructions, descriptions, and technical data are presented in a way that

is functionally equivalent in Arabic. The translation should enable the same kind of user actions or understanding as the original English text, which is crucial for manuals, specifications, and other technical documentation.

2. Semantic Equivalence: This aspect of the model assesses the accuracy of the content transferred from the source text to the target text. For technical translations, semantic precision is paramount. The technical terms, jargon, and specialized language used in the source document must be accurately and appropriately conveyed in Arabic. This ensures that the fundamental technical information remains intact and is understandable to the target audience without ambiguity.

House's (1997) Translation Quality Assessment Model has been adopted as the conceptual framework because of the comprehensive evaluative power it has, including linguistic accuracy and the functional presentation that technical texts demand. Its applicability to technical translations stems from the fact that it has a dual attention to semantic and pragmatic factors that allow it to comprehensively gauge the practicability and use of translated texts. The model aids in the identification of shortcomings of machine translations and highlighting areas that call for the intervention of human post-editing and therefore the improvement of machine translation systems and the training of translators. The emphasis it also has on the vital role that translators play in the provision of good translations aligns perfectly with the study's focus on the process of post-editing. The application of House's TQA Model within the conceptual framework of this study forms a systematic and theoretically grounded framework of measuring the quality of technical machine translations of English-Arabic language pairs. It supports the investigation of how far such translations meet the strict standards of technical communication and finally the development of better translation methods and technologies.

5. Findings and Discussion

5.1 Analysis of Machine translation and post-editing

This section provides the analysis of data machine translation as well as post-editing. As explained in the methodology section, this data is analysed based on House's Translation quality assessment as follows:

Table 1: Machine Translation and Post-Editing of Technical Text No.1

Source text	Google Translation	Post-editing
This appliance is guaranteed by United for one year from date of purchase for house use and six months for saloons and coffeurs. In case of malfunctioning during guarantee time, the dryer will be replaced with new one.	هذا الجهاز مضمون من قبل شركة يونايتد لمدة عام من تاريخ الشراء للاستخدام المنزلي وستة أشهر للاستخدام في الصالونات والمقاهي. في حالة حدوث عطل أثناء فترة الضمان، سيتم استبدال المجفف بآخر جديد.	تضمن شركة يونايتد هذا المنتج لمدة عام من تاريخ الشراء في حالة الاستخدام المنزلي، ولمدة ستة أشهر عند استخدامه في الصالونات والكوافير،وفي حال حدوث عطل في جهاز المجفف خلال فترة الضمان، يتم استبداله بجهاز جديد.

The Google-translated Arabic text exhibits several pragmatic and semantic issues that require post-editing interventions to enhance accuracy and readability. One of the primary concerns with the machine translation is the misrepresentation of company responsibility. The phrase "هذا الجهاز مضمون من قبل شركة يونايتد" fails to fully convey the intended meaning of the English source text, which states "This appliance is guaranteed by United." In Arabic, the verb "تضمن" (guarantees) is more appropriate because it conveys a direct commitment by the company, rather than a passive warranty statement. The post-edited version corrects this by using "تضمن شركة يونايتد هذا المنتج," ensuring a more precise pragmatic equivalence.

Another significant issue arises in the translation of usage conditions. The Google-translated text renders "house use" and "saloons and coffeurs" as "الاستخدام المنزلي" و"الصالونات والمقاهي". However, this translation contains terminological errors. The term "coiffeurs" refers to hairdressers in French, but Google Translate rendered it as "المقاهي" (cafés) instead of "الكوافير" (a commonly used Arabic term for hair salons). Additionally, "saloons" in English can mean bars, which is an incorrect term in this context. This reflects Google Translate's difficulty in distinguishing context-specific terminology. The post-edited version corrects these errors by using "الصالونات والكوافير", which aligns with the industry norms and the intended meaning of the English source text.

From a semantic equivalence perspective, the phrase "In case of malfunctioning during guarantee time, the dryer will be replaced with new one" was translated by Google as "في حالة حدوث عطل أثناء فترة الضمان، سيتم استبدال المجفف بآخر جديد." While generally understandable, it contains a literal translation of "guarantee time" as "فترة الضمان", which is less precise than "مدة الضمان" (warranty period). Furthermore, "malfunctioning" does not explicitly cover all failure scenarios, while "عطل" is broader and better

conveys the intended meaning of functional failure. Additionally, the phrase "بآخر جديد" is somewhat redundant in Arabic, and a clearer alternative like "بجهاز جديد" was preferred in the post-edited version.

Overall, this analysis highlights key deficiencies in Google Translate's Arabic output, particularly in pragmatic accuracy, contextual terminology, and semantic precision. The machine translation struggles with accurately conveying corporate responsibility, adapting industry-specific terms, and maintaining natural phrasing. The post-editing process successfully refines these issues, ensuring both functional and cultural appropriateness. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully account for contextual and industry-specific nuances.

Table 2: Machine Translation and Post-Editing of Technical Text No. 2

Source text	Google Translation	Post-editing
United Professional Dryers are distinguished with its quality, unlike other products if the dryer is damaged we will replace it with a new one but the replaced dryer will not be guaranteed anymore.	تتميز مجففات يونايتد بروفيشنال بجودتها على عكس المنتجات الأخرى إذا تعرض المجفف للتلف نقوم باستبداله بآخر جديد ولكن المجفف المستبدل لن يكون مضمونًا بعد الآن.	تتميز منتجات يونايتد بروفيشنال بجودتها مقارنةً بجميع الأجهزة الأخرى،وفي حال حدوث عطل في الجهاز، سنقوم باستبداله بجهاز جديد، على عكس الشركات الأخرى التي تكتفي بالإصلاح فقط، علمًا أنه عند استبدال الجهاز بجهاز جديد، يتوقف الضمان تلقائيًا.

The Google-translated Arabic text presents several pragmatic and semantic issues that required post-editing interventions to ensure accuracy and alignment with the English source text. One of the primary issues with the machine translation is the lack of clarity in comparative quality statements. The English source text states: "United Professional Dryers are distinguished with its quality, unlike other products," but the Google-translated version "تتميز مجففات يونايتد بروفيشنال بجودتها على عكس المنتجات الأخرى" is less precise. The post-edited version refines this by using "تتميز منتجات يونايتد بروفيشنال بجودتها مقارنةً بجميع الأجهزة الأخرى", which offers a more natural comparison structure in Arabic and aligns better with the source text's meaning.

Another major issue in the Google-translated text is inaccurate conditional phrasing. The phrase "if the dryer is damaged we will replace it with a new one" was rendered as "إذا تعرض المجفف للتلف نقوم باستبداله بآخر جديد." This translation lacks pragmatic equivalence because "تعرض المجفف للتلف" sounds unnatural and does not precisely convey the conditional failure scenario in a professional warranty context. The post-edited version corrects this by using "وفي حال حدوث عطل في الجهاز، سنقوم باستبداله بجهاز جديد," ensuring that the intended meaning is accurately conveyed in a way that suits a technical warranty statement.

From a semantic equivalence perspective, the phrase "but the replaced dryer will not be guaranteed anymore" was translated by Google as "ولكن المجفف المستبدل لن يكون مضمونًا بعد الآن." This phrase is grammatically and structurally awkward in Arabic. Additionally, "لن يكون مضمونًا بعد الآن" is too informal for a technical warranty document. The post-edited version corrects this by stating "علمًا أنه عند استبدال الجهاز بجهاز جديد، يتوقف الضمان تلقائيًا," which is a more precise and professional way of stating that the warranty coverage ceases upon replacement.

This analysis highlights significant linguistic and technological challenges in machine translation, particularly regarding comparative expressions, conditional statements, and warranty phrasing. Google Translate struggled with pragmatic accuracy, often producing unnatural sentence structures and literal translations that failed to capture the intended communicative function of the source text. The post-editing process successfully refined these issues, ensuring cultural and contextual appropriateness, enhanced readability, and professional tone in the translated Arabic text. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully account for context-sensitive expressions and industry-specific terminology.

Table 3: Machine Translation and Post-Editing of Technical Text No. 3

Source text	Google Translation	Post-editing
The following are excluded: all damages resulting from improper use, negligence, break or motor damage with high voltage or repair by unauthorized person. Note that motor is Japanese made and switches as well. As well, the parts subject to normal wear (carbons) are excluded.	يتم استبعاد ما يلي: جميع الأضرار الناتجة عن سوء الاستخدام أو الإهمال أو الكسر أو تلف المحرك بجهد عالي أو الإصلاح بواسطة شخص غير مصرح له. يرجى ملاحظة أن المحرك والمفاتيح مصنوعة في اليابان. كما يتم استبعاد الأجزاء المعرضة للتآكل الطبيعي (الكربون).	يُستثنى من هذا الضمان جميع الأعطال الناتجة عن سوء الاستخدام او الإهمال او الكسر أو تلف المحرك بسبب التيار الكهربائي العالي، بالإضافة إلى عمليات الإصلاح التي تُجرى في مراكز صيانة غير معتمدة. علمًا أن المحرك والمفاتيح يابانية الصنع، كما تُستثنى أيضًا الأجزاء المعرضة للتآكل الطبيعي (الفحمات).

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to ensure clarity and alignment with the English source text. One of the primary issues in the machine translation is the incorrect rendering of exclusions and conditions. The English source text states: "The following are excluded: all damages resulting from improper use, negligence, break or motor damage with high voltage or repair by unauthorized person." The Google translation renders this as " يتم استبعاد ما يلي: جميع الأضرار الناتجة عن سوء الاستخدام أو الإهمال أو الكسر أو تلف المحرك بجهد عالي أو الإصلاح بواسطة شخص غير مصرح له." This translation introduces structural awkwardness and terminological inaccuracies, particularly in "جهد عالي", which is an unnatural phrasing for "high voltage". The post-edited version corrects this to "تلف المحرك بسبب التيار الكهربائي العالي", ensuring a more technically precise and contextually appropriate translation.

Another issue arises in the translation of exclusions and limitations. The phrase "repair by unauthorized person" was translated by Google as " الإصلاح بواسطة شخص غير مصرح له", which is grammatically correct but does not reflect the formal register of warranty statements. The post-edited version refines this by stating "عمليات الإصلاح التي تُجرى في مراكز صيانة غير معتمدة," which is a more professional and contextually suitable phrase for a formal document.

From a semantic equivalence perspective, the phrase "As well, the parts subject to normal wear (carbons) are excluded." was translated by Google as "كما يتم استبعاد الأجزاء المعرضة للتآكل الطبيعي (الكربون)." While generally understandable, "الكربون" is not the standard term used in Arabic for "carbons" in a technical context. The post-edited version corrects this by using "الفحمات", which is the accurate industry term.

This analysis highlights significant linguistic and technical translation challenges in machine translation, particularly regarding the precise wording of exclusions, technical terminology, and warranty conditions. Google Translate struggled with pragmatic accuracy, often producing literal translations that lacked clarity, industry-appropriate phrasing, and professional tone. The post-editing process successfully refined these issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully capture industry-specific expressions and formal document structures.

Table 4: Machine Translation and Post-Editing of Technical Text No. 4

Source text	Google Translation	Post-editing
This guarantee is not valid if it is not written and stamped by the dealer clearly, or the date of purchase was not written. Also if it is not enclosed with invoice, or when the date of purchase has been altered.	لا يكون هذا الضمان صالحًا إذا لم يكن مكتوبًا ومختومًا من قبل التاجر بشكل واضح، أو لم يتم كتابة تاريخ الشراء، وكذلك إذا لم يكن مرفقًا بالفاتورة، أو إذا تم تغيير تاريخ الشراء.	لا تكون هذه الضمانة سارية المفعول ما لم يتم تعبئتها بوضوح وتوقيعها وختمها من قبل الموزع المعتمد،مع تدوين تاريخ الشراء أيضاً وأن تكون مرفقة بفاتورة الشراء، كما تلغي صلاحيتها إذا تم تغيير تاريخ الشراء.

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to align with the English source text. One of the primary issues in the machine translation is the lack of formal and precise phrasing in warranty-related conditions. The English source text states: "This guarantee is not valid if it is not written and stamped by the dealer clearly, or the date of purchase was not written." Google Translate renders this as " لا يكون هذا الضمان صالحًا إذا لم يكن مكتوبًا ومختومًا من قبل التاجر بشكل واضح."

This translation introduces several problems:

1. "لا يكون هذا الضمان صالحًا" (This warranty will not be valid) is a direct literal translation that lacks the professional tone required for warranty statements. The post-edited version corrects this to "لا تكون هذه الضمانة سارية المفعول," which is a more legally appropriate phrase in Arabic.
2. "إذا لم يكن مكتوبًا ومختومًا من قبل التاجر" (if it is not written and stamped by the dealer) is grammatically correct but not contextually precise. The post-edited version refines this to "ما لم يتم تعبئتها بوضوح وتوقيعها وختمها من قبل الموزع المعتمد," ensuring clarity, specificity, and correct formal structure.

Another issue is the translation of conditions regarding the purchase date and invoice. The English phrase "Also if it is not enclosed with invoice, or when the date of purchase has been altered." was translated by Google as " وكذلك إذا لم يكن مرفقًا بالفاتورة، أو إذا تم تغيير تاريخ الشراء." While this is understandable, it lacks the precise warranty phrasing typically used in Arabic. The post-edited version corrects this by using "وأن تكون مرفقة بفاتورة الشراء، كما تلغي صلاحيتها إذا تم تغيير تاريخ الشراء." This provides better semantic equivalence and a clearer, more formal legal tone.

This analysis highlights significant linguistic and legal translation challenges in machine translation, particularly regarding the structured wording of warranty conditions and the use of formal register. Google Translate struggled with pragmatic accuracy, often producing literal translations that lacked clarity, legal appropriateness, and professional tone. The post-editing process successfully refined these issues, ensuring a more structured, precise, and legally sound Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully capture the nuances of legally binding documents.

Table 5: Machine Translation and Post-Editing of Technical Text No. 5

Source text	Google Translation	Post-editing
Your vehicle is equipped with electronic fuel injection and other electronic components. It is possible for an improperly installed/adjusted two-way radio or cellular telephone to adversely affect electronic systems. For this reason, we recommend that you carefully follow the radio manufacturer's instructions or consult your Hyundai dealer for precautionary measures or special instructions if you choose to install one of these devices.	تم تجهيز سيارتك بنظام حقن الوقود الإلكتروني ومكونات إلكترونية أخرى. من الممكن أن يؤثر جهاز الراديو ثنائي الاتجاه أو الهاتف الخلوي غير المثبت/المضبوط بشكل صحيح سلبًا على الأنظمة الإلكترونية. لهذا السبب، نوصيك باتباع تعليمات الشركة المصنعة لجهاز الراديو بعناية أو استشارة وكيل هيونداي الخاص بك للحصول على تدابير احترازية أو تعليمات خاصة إذا اخترت تثبيت أحد هذه الأجهزة.	تم تزويد سيارتك بنظام إلكتروني لحقن الوقود ومكونات إلكترونية أخرى. قد يؤدي التركيب أو الضبط غير المناسب لجهاز الراديو ثنائي الاتجاه أو الهاتف المحمول إلى التأثير سلبًا على الأنظمة الإلكترونية. لذلك، نوصي باتباع تعليمات الشركة المصنعة للراديو بدقة، أو استشارة وكيل هيونداي المعتمد لاتخاذ الإجراءات الوقائية اللازمة أو الحصول على تعليمات خاصة عند تركيب أحد هذه الأجهزة.

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to ensure clarity and alignment with the English source text. One of the primary issues with the machine translation is the improper rendering of technical terms. The English source text states: "Your vehicle is equipped with electronic fuel injection and other electronic components." Google Translate renders this as "تم تجهيز سيارتك بنظام حقن الوقود الإلكتروني ومكونات إلكترونية أخرى."While this translation is technically understandable, it lacks pragmatic accuracy. The post-edited version refines this to " تم تزويد سيارتك بنظام إلكتروني لحقن الوقود ومكونات إلكترونية أخرى," which is a more natural and accurate phrasing in Arabic for technical automotive manuals.

Another issue arises in the translation of cause-effect relationships and conditional phrasing. The phrase "It is possible for an improperly installed/adjusted two-way radio or cellular telephone to adversely affect electronic systems." was translated by Google as "من الممكن أن يؤثر جهاز الراديو ثنائي الاتجاه أو الهاتف الخلوي غير المثبت/المضبوط بشكل صحيح سلبًا على الأنظمة الإلكترونية." While this sentence is grammatically correct, it is less fluid and lacks technical precision. The post-edited version refines this by stating "قد يؤدي التركيب أو الضبط غير المناسب لجهاز الراديو ثنائي الاتجاه أو الهاتف المحمول سلبًا إلى التأثير على الأنظمة الإلكترونية," which improves readability and naturalness in Arabic.

From a semantic equivalence perspective, the phrase "For this reason, we recommend that you carefully follow the radio manufacturer's instructions or consult your Hyundai dealer for precautionary measures or special instructions if you choose to install one of these devices." was translated by Google as "لهذا السبب، نوصيك باتباع تعليمات الشركة المصنعة لجهاز الراديو بعناية أو استشارة وكيل هيونداي الخاص بك للحصول على تدابير احترازية أو تعليمات خاصة إذا اخترت تثبيت أحد هذه الأجهزة." While functionally acceptable, this translation lacks a formal and instructional tone expected in technical documents. The post-edited version corrects this to "لذلك، نوصي باتباع تعليمات الشركة المصنعة للراديو بدقة، أو استشارة وكيل هيونداي المعتمد لاتخاذ الإجراءات الوقائية اللازمة أو الحصول على تعليمات خاصة عند تركيب أحد هذه الأجهزة," ensuring greater formality and a more authoritative voice.

This analysis highlights key translation challenges in technical automotive manuals, particularly regarding technical terminology, conditional phrasing, and instructional tone. Google Translate struggled with pragmatic accuracy, producing literal translations that lacked clarity, technical fluency, and appropriate register for automotive texts. The post-editing process successfully refined these issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully capture technical nuances and maintain formal consistency in instructional manuals.

Table 6: Machine Translation and Post-Editing of Technical Text No. 6

Source text	Google Translation	Post-editing
We want to help you get the greatest possible driving experience from your vehicle. Your Owner's Manual can assist you in many ways. We strongly recommend that you read the entire manual. In order to minimize the chance of death or injury, you must read the WARNING and CAUTION sections in the manual.	نحن نريد أن نساعدك في الحصول على أفضل تجربة قيادة ممكنة من سيارتك. يمكن أن يساعدك دليل المالك الخاص بك بعدة طرق. نوصيك بشدة بقراءة الدليل بالكامل. لتقليل احتمالية الوفاة أو الإصابة، يجب عليك قراءة أقسام التحذير والتحذير في الدليل.	نحرص على مساعدتك في تحقيق أفضل تجربة قيادة ممكنة لسيارتك. يمكن أن يفيدك دليل المالك بطرق عديدة، لذا نوصي بشدة بقراءته بالكامل. وللحد من مخاطر الوفاة أو الإصابة، يجب قراءة أقسام التحذير والتنبيه الواردة في الدليل بعناية.

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to enhance clarity and alignment with the English source text. One of the key issues in the machine translation is the unnatural and overly literal phrasing. The English source text states: "We want to help you get the greatest possible driving experience from your vehicle." Google Translate renders this as "نحن نريد أن نساعدك في الحصول على أفضل تجربة قيادة ممكنة من سيارتك." While this translation is grammatically correct, it is unnatural in Arabic because of the redundant "نحن نريد" (we want). The post-edited version corrects this by using "نحرص على مساعدتك في تحقيق أفضل تجربة قيادة ممكنة لسيارتك," which is a more fluent and natural construction that better conveys the intended meaning.

Another issue arises in the translation of instructional content. The phrase "Your Owner's Manual can assist you in many ways." was translated by Google as "يمكن أن يساعدك دليل المالك الخاص بك بعدة طرق." While this is generally understandable, the phrase "دليل المالك الخاص بك" is unnecessarily possessive and repetitive, making the sentence sound unnatural. The post-edited version refines this to "يمكن أن يفيدك دليل المالك بطرق عديدة," ensuring a more fluid and formal instructional tone.

From a semantic equivalence perspective, the phrase "In order to minimize the chance of death or injury, you must read the WARNING and CAUTION sections in the manual." was translated by Google as "لتقليل احتمالية الوفاة أو الإصابة، يجب عليك قراءة أقسام التحذير والتحذير في الدليل." This translation introduces two major errors:

1. "احتمالية الوفاة" is a direct translation of "chance of death", but it lacks the urgency and seriousness of the original phrase. The post-edited version uses "للحد من مخاطر الوفاة أو الإصابة," which is a more accurate and natural way to convey safety warnings.
2. "أقسام التحذير والتحذير" is a duplication error, where "WARNING" and "CAUTION" were both translated as "تحذير". The post-edited version corrects this to "أقسام التحذير والتنبيه," ensuring the differentiation between the two terms as intended in the English source text.

This analysis highlights key translation challenges in technical manuals, particularly regarding instructional tone, redundancy, and safety warnings. Google Translate struggled with pragmatic accuracy, often producing literal and repetitive translations that failed to maintain clarity, formal structure, and the serious tone required for safety instructions. The post-editing process successfully refined these issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully account for nuanced phrasing, formal register, and contextual accuracy in user manuals.

Table 7: Machine Translation and Post-Editing of Technical Text No. 7

Source text	Google Translation	Post-editing
Illustrations complement the text in this manual to best explain how to use your vehicle. By reading your manual, you will learn about features, important safety information, and driving tips under various road conditions.	تكمل الرسوم التوضيحية النص الموجود في هذا الدليل لتوضيح كيفية استخدام سيارتك بشكل أفضل. من خلال قراءة الدليل، ستتعرف على الميزات ومعلومات السلامة المهمة ونصائح القيادة في ظل ظروف الطريق المختلفة.	تساعد الرسوم التوضيحية في هذا الدليل على توضيح كيفية استخدام سيارتك بشكل أفضل،ومن خلال قراءة الدليل، ستتعرف على الميزات، والمعلومات الهامة المتعلقة بالسلامة، ونصائح القيادة وفقا لظروف الطريق المختلفة.

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to ensure clarity, fluency, and alignment with the English source text. One of the key issues in the machine translation is the unnatural rendering of the function of illustrations. The English source text states: "Illustrations complement the text in this manual to best explain how to use your vehicle." Google Translate renders this as " تكمل الرسوم التوضيحية النص الموجود في هذا الدليل لتوضيح كيفية استخدام سيارتك بشكل أفضل."

While this translation is grammatically correct, it fails to convey the function of the illustrations naturally in Arabic. The post-edited version refines this by using "تساعد الرسوم التوضيحية في هذا الدليل على توضيح كيفية استخدام سيارتك بشكل أفضل," which is a more natural and accurate construction that clarifies the role of illustrations as supporting aids rather than direct complements to the text.

Another issue arises in the translation of "important safety information." The phrase "By reading your manual, you will learn about features, important safety information, and driving tips under various road conditions." was translated by Google as " من خلال قراءة الدليل، ستتعرف على الميزات ومعلومات السلامة المهمة ونصائح القيادة في ظل ظروف الطريق المختلفة." While this is generally understandable, the phrase "معلومات السلامة المهمة" is less natural and lacks the formal instructional tone typically used in Arabic automotive manuals. The post-edited version refines this to "المعلومات الهامة المتعلقة بالسلامة," ensuring a more structured and authoritative phrasing.

From a semantic equivalence perspective, the phrase "under various road conditions" was translated by Google as " في ظل ظروف الطريق المختلفة," which is technically correct but sounds slightly unnatural in Arabic. The post-edited version modifies this to " وفقا لظروف الطريق المختلفة," which is a more fluent and commonly used phrasing in Arabic for technical contexts.

This analysis highlights key translation challenges in technical manuals, particularly regarding the precise function of illustrations, instructional tone, and structured phrasing. Google Translate struggled with pragmatic accuracy, often producing literal translations that failed to maintain clarity, fluency, and an authoritative instructional tone. The post-editing process successfully refined these issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully adapt instructional texts to industry-specific and reader-friendly formats.

Table 8: Machine Translation and Post-Editing of Technical Text No. 8

Source text	Google Translation	Post-editing
For maximum effectiveness in case of an accident, the headrest should be adjusted so the middle of the headrest is at the same height of the center of gravity of an occupant's head. Generally, the center of gravity of most people's head is similar with the height of the top of their eyes. Also, adjust the headrest as close to your head as possible. For this reason, the use of a cushion that holds the body away from the seatback is not recommended.	لضمان أقصى فعالية في حالة وقوع حادث، يجب ضبط مسند الرأس بحيث يكون وسط المسند على نفس ارتفاع مركز ثقل رأس الراكب. بشكل عام، مركز ثقل رأس معظم الأشخاص يكون مشابهًا لارتفاع أعلى العينين. كذلك، يُنصح بضبط مسند الرأس بأقرب ما يمكن إلى رأسك. لهذا السبب، لا يُنصح باستخدام وسادة تبعد الجسم عن ظهر المقعد.	لضمان أقصى فعالية في حالة وقوع حادث، يجب ضبط مسند الرأس بحيث يكون منتصفه على مستوى مركز ثقل رأس الراكب. عمومًا، يتوافق مركز ثقل رأس معظم الأشخاص مع ارتفاع أعلى أعينهم، كما يُفضل ضبط مسند الرأس بحيث يكون قريبًا قدر الإمكان من الرأس. لذا، يُنصح بتجنب استخدام الوسائد التي تبعد الجسم عن مسند الظهر.

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to improve clarity, accuracy, and alignment with the English source text. One of the key issues in the machine translation is the unnatural rendering of technical adjustments. The English source text states: "For maximum effectiveness in case of an accident, the headrest should be adjusted so the middle of the headrest is at the same height of the center of gravity of an occupant's head." Google Translate renders this as "لضمان أقصى فعالية في حالة وقوع حادث، يجب ضبط مسند الرأس بحيث يكون وسط المسند على نفس ارتفاع مركز ثقل رأس الراكب." While this translation is structurally acceptable, the phrase "وسط المسند" (middle of the headrest) sounds less precise than the more accurate and commonly used "منتصفه" in Arabic. The post-edited version refines this to " يجب ضبط مسند الرأس بحيث يكون منتصفه على مستوى مركز ثقل رأس الراكب," ensuring a more natural and technically accurate phrasing.

Another issue arises in the translation of the comparison statement. The phrase "Generally, the center of gravity of most people's head is similar with the height of the top of their eyes." was translated by Google as " بشكل عام، مركز ثقل رأس معظم الأشخاص يكون مشابهًا لارتفاع أعلى العينين." While grammatically correct, the phrase "مشابهًا لارتفاع" is less natural in Arabic. The post-edited version corrects this by using "يتوافق مركز ثقل رأس معظم الأشخاص مع ارتفاع أعلى أعينهم," which provides a smoother and more naturally structured sentence.

From a semantic equivalence perspective, the phrase "For this reason, the use of a cushion that holds the body away from the seatback is not recommended." was translated by Google as "لهذا السبب، لا يُنصح باستخدام وسادة تبعد الجسم عن ظهر المقعد." While this is understandable, the phrasing is somewhat rigid and lacks the precise technical advisory tone expected in automotive manuals. The post-edited version refines this to "لذا، يُنصح بتجنب استخدام الوسائد التي تبعد الجسم عن مسند الظهر," ensuring a more fluid and formal tone that aligns with the structure of professional automotive instructions.

This analysis highlights key translation challenges in automotive safety instructions, particularly in technical adjustments, comparative statements, and advisory phrasing. Google Translate struggled with pragmatic accuracy, producing literal translations that failed to maintain clarity, fluency, and a precise instructional tone. The post-editing process successfully refined these issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully account for technical nuances and industry-standard expressions in safety guidelines.

Table 9: Machine Translation and Post-Editing of Technical Text No. 9

Source text	Google Translation	Post-editing
No modifications or additions should be made by the user which will either prevent the seat belt adjusting devices from operating to remove slack, or prevent the seat belt assembly from being adjusted to remove slack.	لا ينبغي للمستخدم إجراء أي تعديلات أو إضافات من شأنها أن تمنع أجهزة ضبط حزام الأمان من العمل لإزالة الارتخاء، أو تمنع مجموعة حزام الأمان من التعديل لإزالة الارتخاء	يجب عدم إجراء أي تعديلات أو إضافات من قبل المستخدم قد تعيق عمل أجهزة ضبط حزام الأمان أو تمنع ضبطه لإزالة الإرتخاء.

The Google-translated Arabic text presents several pragmatic and semantic inaccuracies that required post-editing to ensure clarity, fluency, and alignment with the English source text. One of the key issues in the machine translation is the unnatural structuring of technical instructions. The English source text states:

"No modifications or additions should be made by the user which will either prevent the seat belt adjusting devices from operating to remove slack, or prevent the seat belt assembly from being adjusted to remove slack." Google Translate renders this as: " لا ينبغي للمستخدم إجراء أي تعديلات أو إضافات من شأنها أن تمنع أجهزة ضبط حزام الأمان من العمل لإزالة الارتخاء، أو تمنع مجموعة حزام الأمان من التعديل لإزالة الارتخاء." While the general meaning is conveyed, the translation lacks technical precision and introduces redundancy. Specifically, the phrase "أجهزة ضبط حزام الأمان" (seat belt adjusting devices) and "مجموعة حزام الأمان" (seat belt assembly) are not differentiated clearly, making the statement less structured. The post-edited version refines this to " يجب عدم إجراء أي تعديلات أو إضافات من قبل المستخدم قد تعيق عمل أجهزة ضبط حزام الأمان أو تمنع ضبطه لإزالة الارتخاء," ensuring a more concise and technically accurate translation.

Another issue arises in the translation of prohibition and restriction. The phrase "No modifications or additions should be made by the user" was translated by Google as "لا ينبغي للمستخدم إجراء أي تعديلات أو إضافات". While this is grammatically acceptable, the phrase "لا ينبغي" is less direct than "يجب عدم", which is a stronger and more precise instruction typically used in technical and safety warnings. The post-edited version corrects this by using "يجب عدم إجراء أي تعديلات أو إضافات من قبل المستخدم," ensuring a clearer and more authoritative tone that aligns with formal safety regulations. From a semantic equivalence perspective, the phrase "to remove slack" was correctly translated as "لإزالة الارتخاء", but the Google-translated text unnecessarily repeats it in two clauses. The post-edited version improves readability by simplifying the structure while maintaining the full meaning.

This analysis highlights key translation challenges in safety and technical instructions, particularly regarding the structuring of prohibitive statements, technical terminology, and redundancy. Google Translate struggled with pragmatic accuracy, often producing literal and repetitive translations that lacked clarity, directness, and the formal instructional tone required in technical documents. The post-editing process successfully refined these issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation still lacks the ability to fully adapt safety instructions to professional standards in the automotive industry.

Table 10: Machine Translation and Post-Editing of Technical Text No. 10

Source text	Google Translation	Post-editing
The detector automatically checks the condition of the batteries.	يتحقق جهاز الكشف تلقائيًا من حالة البطاريات.	يقوم الكاشف بفحص حالة البطاريات تلقائيًا.

The Google-translated Arabic text presents minor semantic and pragmatic issues that required post-editing to enhance clarity and alignment with the English source text. The English source text states: "The detector automatically checks the condition of the batteries." Google Translate renders this as: "يتحقق جهاز الكشف تلقائيًا من حالة البطاريات." While this translation is generally correct and understandable, it introduces an unnecessary shift in terminology and structure that slightly affects the pragmatic equivalence. The phrase "يتحقق جهاز الكشف" translates to "The detector verifies," which is slightly different in nuance from "checks", as the latter

implies a routine or automated process, whereas "يتحقق" (verifies) suggests a deliberate or manual inspection. The post-edited version corrects this by using "يقوم الكاشف بفحص حالة البطاريات تلقائيًا," ensuring a more direct and functionally accurate translation.

Another issue arises in the translation of "detector". While "جهاز الكشف" is a technically correct translation, the more commonly used term for "detector" in technical Arabic is "الكاشف". The post-edited version refines this by replacing "جهاز الكشف" with "الكاشف," making the text more fluid and standard in Arabic technical contexts. From a semantic equivalence perspective, the phrase "automatically checks" was correctly rendered as "تلقائيًا", and there was no need for further adjustments in this part of the sentence.

This analysis highlights subtle translation challenges in technical instructions, particularly regarding terminology accuracy and verb selection. Google Translate produced a translation that was generally correct but slightly off in nuance, leading to a less precise technical instruction. The post-editing process successfully refined these minor issues, ensuring a more structured, precise, and professional Arabic translation. These findings reinforce the necessity of human intervention in post-editing technical translations, as machine translation sometimes selects terms that, while grammatically correct, do not fully align with the intended technical meaning.

5.2 Analysis of Interviews

The responses of the translators who were interviewed provide valuable insight into the challenges of post-editing English-to-Arabic machine translation (MT) of technical texts. Their opinions align with the three research questions of the study, highlighting linguistic and technological challenges and potential improvements to MT systems. What follows is an analysis of their responses based on each research question.

5.2.1 Technological Limitations of Current Machine Translation Systems

The interviews reveal several technological constraints that contribute to the post-editing effort. Among the predominant issues is MT's inability to comprehend context, which leads to the inappropriateness of word choice and lack of specificity in technical terminology. One of the consistent issues is the fact that English technical terms have multiple connotations, yet MT has a propensity to choose the incorrect equivalent, and manual corrections are necessary.

Inconsistent translation of terminology is another essential limitation. MT tools are not able to provide consistent translations of technical terms throughout a document, leading to inconsistencies that interfere with coherence and readability. Furthermore, grammatical errors were found to be a significant issue. MT has problems with Arabic morphology, including gender agreements, verb conjugation, and pluralization, which adds considerably to post-editing time.

Sentence structure and fluency also present challenges. Arabic and English follow different syntactic structures, and MT often produces rigid, unnatural word order, making the text mechanical and difficult to read. Furthermore, MT struggles with long, complex sentences, frequently breaking them into disjointed, fragmented phrases, which require extensive rewriting. Thus, the primary technological limitations that contribute to the post-editing workload include context misinterpretations in technical terminology, inconsistent translation of repeated terms within a document, grammatical errors in morphology and syntax, and poor sentence structure and unnatural phrasing.

5.2.2 Impact of Linguistic Differences Between English and Arabic on MT Accuracy

The linguistic differences between English and Arabic pose significant challenges for MT, affecting both accuracy and reliability. The interviews highlight that Arabic's complex morphology and syntax make it difficult for MT tools to produce fluent, readable translations. One of the major linguistic challenges is word order mismatches. English follows an SVO (Subject-Verb-Object) structure, while Arabic allows VSO (Verb-Subject-Object) and other variations. MT fails to adjust for these differences, often producing awkward and unnatural Arabic sentences.

Another challenge is terminology and domain specificity. MT lacks sensitivity to industry-specific jargon, often choosing generic or incorrect equivalents instead of precise, standardized technical terms. This leads to misinterpretations and confusion, particularly in highly specialized texts. Additionally, MT does not effectively distinguish between formal and informal registers, sometimes producing translations that are too casual for technical documentation.

Negations and conditional expressions present another area of difficulty. MT frequently mistranslates these structures, altering the intended meaning of safety warnings and instructions. Imperative statements in English sometimes become weakened into mere suggestions in Arabic, which can be problematic in instructional or regulatory texts. Additionally, Arabic has grammatical gender and complex inflectional rules, which MT often fails to handle correctly. Errors in gender agreements and verb conjugations require extensive manual correction, further increasing post-editing time.

The key linguistic differences affecting MT accuracy include word order mismatches between English (SVO) and Arabic (VSO), incorrect handling of technical terminology and industry-specific jargon, failure to distinguish between formal and informal registers, errors in negations, conditionals, and imperative structures and mistakes in gender agreements and morphological inflections.

5.2.3 Proposed Improvements in Machine Translation Technology

Several improvements were suggested to enhance MT output and reduce the post-editing workload. One major recommendation is enhancing AI-driven context analysis to improve word choice, terminology selection, and sentence structure. Current MT systems fail to recognize domain-specific meanings, leading to frequent misinterpretations of technical terms. A more advanced AI model that analyzes surrounding text and previous translations could improve consistency and accuracy.

Another important improvement is customizable glossaries and domain-specific training. Translators should have the ability to upload terminology databases into MT tools so that pre-approved translations are prioritized, ensuring greater terminology consistency and reducing manual corrections. Additionally, a sentence restructuring feature would be beneficial, allowing MT tools to offer alternative phrasings rather than just one direct translation. This would give translators greater flexibility in selecting the most natural sentence structure, improving fluency.

Further, improved grammatical correction mechanisms were recommended. MT struggles with Arabic morphology, and integrating automated grammar correction tools for verb conjugations, gender agreements, and syntax adjustments would greatly enhance translation quality. Another suggested improvement is adaptive learning capabilities. If MT tools could learn from previous post-edits, they could gradually improve accuracy over time, reducing the recurrence of common errors.

The key suggested improvements in MT technology include:

a) Enhanced AI-driven context analysis for better word choice and terminology selection.
b) Customizable glossaries and domain-specific terminology databases to improve consistency.
c) A sentence restructuring feature that offers alternative phrasings.
d) Advanced grammatical correction mechanisms for Arabic morphology.
e) Adaptive learning capabilities to improve accuracy over time.

The interviews reveal that while machine translation is a useful asset, a great deal of human intervention is required to attain accuracy, clearness, and technicality in the translation of technical documents into Arabic language. The findings identify the technology and linguistic barriers that make the process of post-editing difficult, specifically issues associated with the misunderstanding of contexts, non-conforming terminologies, syntactic errors, and inappropriate management of the morphology of the Arabic language. Solutions proposed against such challenges include the development of AI-enhanced contextual comprehension, custom glossary options, higher-level grammar correction tools, and flexible capabilities. The application of such innovations will enhance the effectiveness of machine translation tools, minimize the time required for the post-editing process, and enhance the general technical translation standard.

6. Conclusions

The findings of this study reveal significant technological and linguistic challenges related to the post-editing of English-to-Arabic machine translation (MT) of technical documents. The assessment of MT output, changes undertaken during post-editing, and interviews with translators reveal that while MT tools offer a rudimentary structure for translation, they continue to require extensive human intervention to ensure accuracy, coherence, and usefulness.

Among the most significant challenges in post-editing is MT's inability to appreciate context, thus misunderstanding technical terminology and incongruent choice of words. The analysis of translated texts and interview responses indicates that MT software

frequently produces flawed or incongruent translation of specialized terms, requiring manual correction by human translators. This is exacerbated by morphological mistakes, gender agreement conflicts, and wrong verb conjugations, all of which interfere with the overall grammatical flow of the Arabic text. Machine translation also grapples with negation and conditional constructions, occasionally distorting the intended meanings of safety instructions and technical information.

Another primary concern is MT's failure to handle sentence structure and fluency. Arabic and English differ in their syntactic composition, and MT generates incoherent and unnatural Arabic sentences. Analysis of post-edited text shows that translators must restructure whole sentences for coherence and readability very frequently. Moreover, MT inconsistencies in rendering repeated terms within the same document pose additional challenges, requiring translators to standardize terms manually.

Linguistic differences between English and Arabic further complicate the MT process. Word order mismatches were observed as a major issue, with English following SVO (Subject-Verb-Object) structure, whereas Arabic allows for VSO (Verb-Subject-Object) and other variations. MT often fails to adjust for these structural differences, resulting in rigid and unnatural Arabic translations that require extensive reworking.

Additionally, MT struggles to differentiate between formal and informal registers, leading to inappropriate translations, particularly in technical documentation. Errors in negation and imperative structures also affect the clarity of safety instructions, sometimes altering the intended cautionary tone. Moreover, Arabic's complex morphological system, including gender agreements, verb conjugations, and pluralization, poses challenges for MT tools, leading to frequent grammatical errors that require manual intervention.

The findings suggest that current MT tools are not yet reliable enough for standalone use in technical translation and require comprehensive post-editing by human translators. The study confirms that MT systems still lack the ability to understand domain-specific contexts and linguistic nuances, which impacts both efficiency and translation quality. Consequently, the post-editing workload remains high, with translators spending significant time correcting grammatical errors, restructuring sentences, and ensuring terminology consistency.

Based on the findings, the study proposes the following recommendations to improve MT performance and reduce the post-editing workload. MT tools should be developed with advanced AI-driven context recognition capabilities to improve word choice and terminology selection. Implementing deep learning algorithms that analyze sentence context helps reduce errors in technical terminology and improve semantic accuracy. To enhance terminology consistency, MT tools should allow translators to upload industry-specific glossaries and have the system prioritize pre-approved translations. Additionally, training MT models on specialized domains (e.g., engineering, medicine, automotive industry) could improve accuracy in technical contexts and reduce post-editing time.

MT tools should incorporate sentence restructuring mechanisms that provide multiple translation options, allowing translators to select the most natural phrasing. A feature that suggests alternative sentence structures would help improve readability and coherence, particularly for complex technical instructions. Since Arabic grammar is highly inflected, MT tools should integrate advanced morphological correction mechanisms to address gender agreement, verb conjugations, and pluralization issues. This would minimize frequent grammatical errors and reduce the need for extensive post-editing. MT systems should also be designed with adaptive learning functionalities that allow them to learn from human post-editing corrections. If MT tools continuously update their models based on previous edits, they could gradually improve accuracy over time, leading to fewer recurring errors. To improve MT outputs, machine translation developers should collaborate more closely with professional translators to better understand the linguistic and technical challenges faced in post-editing. Feedback from experienced translators can help refine MT algorithms and ensure that system updates address real-world translation issues.

ConflictsofInterest: Theauthordeclaresnoconflictofinterest.

References

[1] Akpaca, S. M., Minaflinou, E., &Afolabi, S. (2020). Translation in the Era of Globalisation. *International Journal of Linguistics and Communication, 8*(2), 13-21.

[2] Alanazi, M. S. (2019). *The Use of Computer-Assisted Translation Tools for Arabic Translation: User Evaluation, Issues, and improvements*. Kent State University.

[3] Ali, H., &Sayyiyed Al-Rushaidi, S. M. (2017). Translating Idiomatic Expressions from English into Arabic: Difficulties and Strategies. *Arab World English Journal (AWEJ)* Volume, 7.

[4] Alkhatib, M., &Shaalan, K. (2018). The Key Challenges for Arabic Machine Translation. Intelligent Natural Language Processing: Trends and Applications,*Springer International Publishing*, 139-156.

[5] Ashqar, A. B. M. (2013). *The Problem of Equivalence: The Translation into Arabic of Specialized Technological Texts*, Ph. D. thesis. An-Najah NationalUniversity, Nablus, Palestine.

[6] Besold, T. R., d'AvilaGarcez, A., Bader, S., Bowman, H., Domingos, P., Hitzler, P., ... &Zaverucha, G. (2021). Neural-Symbolic Learning and Reasoning: A Survey and Interpretation 1. In *Neuro-Symbolic Artificial Intelligence: The State of the Art* (pp. 1-51). IOS press.

[7] Churchill, T. (2014). *Modelling Athletic Training and Performance: AHybrid Artificial Neural Network Ensemble Approach,*Ph. D. thesis. University of Canberra.

[8] de Souza, A. A. (2024). *Developing and Evaluating a Machine Translation Model for English-Brazilian Portuguese in the Accounting Domain*, Master thesis.Faculty of Letters, the Federal University of Minas Gerais.

[9] House, J. (1997). *Translation Quality Assessment: A Model Revisited*. Gunter Narr.

[10] Indarti, D. (2024). Investigating the Metacognitive Strategies During Post-Editing Translation Process: An Application of Think-Aloud Protocols (TAP). *Journal of Languages and Language Teaching, 12*(2), 765-778.

[11] Issa, E. S. A. (2016). *English-Arabic Machine Translation: ATransfer Approach*, Ph. D. thesis. Faculty of Arts, Alexandria University, Alexandria.

[12] Kamusella, T. (2017). The Arabic Language: A Latin of Modernity. *Journal of Nationalism, Memory & Language Politics, 11*(2), 117-145.

[13] Koponen, M. (2016a). Is Machine Translation Post-Editing Worth the Effort? A Survey of Research into Post-Editing and Effort. *TheJournal of Specialised Translation, 25*(2), 131-148.

[14] Koponen, M. (2016b). *Machine Translation Post-Editing and Effort: Empirical Studies on the Post-Editing Process*. Unpublished PhD dissertation, University of Helsinki, Faculty of Arts. Retrieved from https://helda. helsinki. fi/bitstream/handle/10138/160256/machinet. pdf.

[15] Marie-Sainte, S. L., Alalyani, N., Alotaibi, S., Ghouzali, S., &Abunadi, I. (2018). Arabic Natural Language Processing and Machine Learning-Based Systems. *IEEE Access, 7,* 7011-7020.

[16] Nieminen, T. (2018). *Multilingual Paraphrase Grammars for Machine Translation Evaluation*, Master thesis. Department of Digital Humanities,University of Helsinki.

[17] Sun, Y. (2010). *An Investigation into Automatic Translation of Prepositions in IT Technical Documentation from English to Chinese*, Ph. D. thesis. Dublin City University.

[18] Tambouratzis, G., Vassiliou, M., &Sofianopoulos, S. (2017). Machine Translation with Minimal Reliance on Parallel Resources. *Springer International Publishing*.

[19] Vieira, L. N. (2019). Post-Editing of Machine Translation. In *The Routledge handbook of translation and technology* (pp. 319-336). Routledge.

[20] Zakraoui, J., Saleh, M., Al-Maadeed, S., &Alja'am, J. M. (2021). Arabic Machine Translation: A Survey with Challenges and Future Directions. *IEEE Access, 9,* 161445-161468.