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E.J. Egamberdieva[1], M.A. Chikhanova[1], M.M. Stepanova[2], D.I. Troitsky[1]

[1]Moscow State Institute of International Relations of the Ministry of Foreign Affairs of Russian Federation (Odintsovo Branch), Odintsovo, Russian Federation
[2]State University of Aerospace Instrumentation, St. Petersburg, Russian Federation

SUBTITLE MACHINE TRANSLATION QUALITY ASSESSMENT

Relevance: In the digital age, audiovisual content comprising text, images, audio, and video is transmitted globally, necessitating efficient translation methods. Audiovisual translation (AVT) is critical for reaching multilingual audiences. Subtitling, a cost-effective method within AVT, faces challenges in accuracy and context preservation when using machine translation (MT).

Materials and Methods**.** This study evaluates the quality of MT for subtitling using TED Talks videos translated from English to Russian. Videos were selected based on content diversity and linguistic complexity. Evaluation methods included Levenshtein distance and BLEU metrics to compare Yandex MT and human translations.

Results: MT quality varied across subjects: technology-related content scored highest (BLEU up to 83.19), while social and environmental topics yielded lower scores (BLEU from 68.20 to 77.42). Errors included lexical inaccuracies, morphological errors, and failure to contextualize metaphors or recognize proper nouns.

Conclusion: MT of subtitles achieves adequate scores for basic comprehension but falls short in accuracy and nuance required for professional translation. Challenges include syntactic complexity, cultural nuances, and the inability to handle non-verbal cues effectively. Human translation remains superior, necessitating post-editing to enhance MT output in AVT applications.

This study underscores the need for further advancements in MT algorithms to address contextual and cultural complexities inherent in audiovisual content translation, crucial for enhancing global communication and accessibility.

Keywords: *audiovisual translation, machine translation, subtitling, BLEU metric, translation quality evaluation, multimodal content*.

Э.Д. Эгамбердиева[1], М.А. Чиханова[1], М.М. Степанова[2], Д.И. Троицкий[1]

[1]Государственный университет аэрокосмического приборостроения, Санкт-Петербург, Российская Федерация
[2]Московский государственный институт международных отношений Министерства иностранных дел Российской Федерации (Одинцовский филиал), Одинцово, Российская Федерация

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АНАЛИЗ КАЧЕСТВА АВТОМАТИЧЕСКОГО ПЕРЕВОДА СУБТИТРОВ

Актуальность. В цифровую эпоху требуются эффективные методы перевода аудиовизуального контента, состоящего из текста, изображений, аудио- и видеоматериалов. Качество аудиовизуального перевода (АВП) имеет решающее значение для охвата многоязычной аудитории. Как показывает практический опыт перевода и результаты исследований, при использовании машинного перевода субтитриров регулярно возникают проблемы точности и сохранения контекста в переводе.

Материалы и методы. В данном исследовании оценивается качество машинного перевода субтитров с английского на русский язык на примере видеолекций TED Talks. Видеоролики для перевода были отобраны с учетом разнообразия содержания и лингвистической сложности. Методы оценки включали расстояние Левенштейна и метрику BLEU для сравнения машинного перевода и перевода, выполненного человеком.

Результаты. Качество машинного перевода варьировалось в зависимости от тематики: контент, связанный с информационными технологиями, получил наивысшие оценки (BLEU до 83,19), в то время как социальные и экологические темы получили более низкие оценки (BLEU от 68,20 до 77,42). Обнаруженные в ходе исследования ошибки включали лексические неточности, морфологические ошибки, неспособность контекстуализировать метафоры и верно распознать имена собственные.

Выводы. Машинный перевод субтитров пригоден для базового понимания, однако не обеспечивает точности, сравнимой с профессиональным переводом. Проблемы вызывают синтаксическая сложность конструкций, культурные нюансы и неспособность эффективно обрабатывать невербальные сигналы. Требуется последующее редактирование машинного перевода человеком. Данное исследование подчеркивает необходимость учета несовершенства алгоритмов машинного перевода при переводе аудиовизуального контента.

Ключевые слова: *аудиовизуальный перевод, машинный перевод, субтитрирование, метрика BLEU, оценка качества перевода, мультимодальный контент.*

Introduction

The advances in technology have changed the way we share information. Now huge amounts of data are transmitted virtually instantly over the Internet and other telecommunication tools. More and more content is not just text, but images, audio, and video. The recipient receives information through multiple channels simultaneously. They not only read/listen to the text but also see the image, which may often contain more information than the text. Translation of such content is called audiovisual translation or AVT [1].

Let us cite A. Kozulyaev: "Audiovisual translation is the creation of a new, integrated, multi-content work in the recipient's language from an integrated work in the source language, and in such a way that the new work seamlessly blends with the recipient's language and culture" [2, p. 21].

Subtitling is extensively utilized in audiovisual translation due to its lower labor and time costs compared to full dubbing and voice-over translation. This method facilitates the rapid release of video content for foreign-language audiences. The steady increase in audiovisual content has prompted the development of automatic translation solutions, some of which are already available on popular video hosting platforms, such as YouTube. Machine translation of subtitles involves an additional stage of speech recognition. In some cases, this significantly reduces the quality of translation, which is already inferior to human translation even without this additional stage.

The purpose of this study is to enhance the quality of machine translation (MT) of subtitles by identifying content that is most susceptible to MT errors. This will facilitate informed decisions regarding the applicability of MT for subtitle translation.

Background

There are many research papers on the translation of movies, advertisements, and computer games. Some of them are purely theoretical, investigating the problems of visual, cultural, and emotional contexts in translation. Practically-oriented research has demonstrated that AVT is a distinct type of translation, necessitating a revision of traditional approaches to the translator's work. One such study is the work of Ana Pilar Orero et al. [3], which emphasizes the importance of non-verbal components in audiovisual content and explains the inadequacy of the linguocentric approach for this type of translation. It was found that non-verbal content conveys more information than verbal content. Therefore, an audiovisual translator must be proficient in cinematography and the principles of video editing. Ana Pilar Orero's team conducted a laboratory study that tracked viewers" eye movements and mapped them using electroencephalography (EEG) and infrared (IR) brain scanning. It was experimentally proven that when watching a documentary, over 60 % of the viewer's perceptual activity is directed towards the video, while only 40 % is focused on speech and text content. As to feature movies, this proportion is 68/32. It proves the dominance of non-verbal information [1]. The researchers concluded that audiovisual content consists of multiple semantic streams. Recipients of audiovisual content simultaneously act as viewers, listeners, and readers, perceiving information through these channels simultaneously. The ratio of these channels continually fluctuates following the video sequence [3, p. 32]. Audiovisual translation requires abandoning the conventional linguocentric approach, which focuses on the text, while the other types of content are just auxiliary components.

It is noteworthy that in AVT, neither the viewer nor the translator can alter the visual content, which occupies the dominant share of the recipient's perceptual channel. In this regard, according to P. Zabalbescoa, the AV translator must know the fundamentals of cinematography, movie language, the logic of script writing, and physiological limitations on the simultaneous perception of two streams [4, p. 21].

Audiovisual translation should adhere to the following principles:

1. Consistency of semantic streams. A skilled AV translator must be fully aware that the verbal and non-verbal components of the content constitute a whole that cannot be separated in translation. Therefore, the translator often has to reconsider conventional approaches to translation. This aspect also includes adhering to the "dynamic equivalence principle" described in [5].

2. Specificity involves having fundamental knowledge in cinematography, directing, psychology, the culture of both the original and target languages, sociology, and other relevant areas essential for accurately interpreting information.

3. Relevance

Subtitling is one of the most commonly used types of AVT. Subtitling refers to the transmission of a spoken message in an audiovisual work through one or more lines of text displayed on the screen and synchronized with the original dialog. In essence, subtitling can be described as a condensed translation of the spoken message conveyed through the audio track. Most often, subtitles are displayed at the bottom of the image/screen. Subtitles are usually arranged in two lines. They appear and disappear in synch with the soundtrack in the foreign language. They are usually incorporated into the audiovisual content during the post-processing stage [6].

Screen space and average reading speed constraints impose limits on the maximum number of lines and characters per line in each subtitle. In subtitles, the original text is significantly condensed to allow viewers sufficient time to read it without diverting attention from the visual content. Ideally, viewers should seamlessly read subtitles while simultaneously following the video without conscious effort.

Subtitle translation, in comparison with other AVT types such as voice-over and lip-sync translations, faces several significant limitations:

1. The number of lines and characters per line is strictly limited to meet the international standards for the speed of reading and subtitling.

2. Subtitles are tied to specific frames and therefore have a time constraint that may not always conform to universally accepted standards.

Therefore, when subtitling, the translator often must finalize the text while accommodating various external constraints, as subtitles are constrained by both time and space [7]. Another crucial factor in subtitling is the playback device. Subtitling for devices with smaller screens, such as tablets and smartphones, requires that the translation remains legible on these compact displays.

The subtitling process involves three main phases: information reduction, transfer, and compression. Reduction involves emphasizing key elements and

eliminating redundant information, such as pauses during hesitation, repetitions, and other elements that do not convey significant meaning from the original text. Transfer includes adaptation of the text for the target audience, and elimination of hate speech, slang, and profanities. Finally, compression means simplifying the syntax of the original to make subtitles more accessible [8].

The advantages of subtitling include cost and time savings compared to dubbing and voice-over, as well as preservation of the original audio track. Drawbacks include partial loss of both semantic and visual information and the loss of the original style and expression.

When translating scientific audiovisual content, it is crucial to maintain the logical emphasis of the message in the original language and preserve the primary characteristics of scientific texts: objectivity, coherence, and reduced emotional tone. Subtitles should correctly render terms, units of measurement, polysemantic words, and abbreviations. It is also essential to either maintain the academic style or adapt it for a broader audience, such as using a popular science style. The translator must possess knowledge of the pertinent subject area [6].

The concept of automated subtitle translation has been under discussion for many years. Recently, some researchers have explored the possibility of utilizing artificial intelligence (AI) to create and translate subtitles, including for educational and scientific content [9–11]. The research focuses on comparing the effects of automated and human-edited subtitles on the perception and retention of educational content. Chan et al. reported: “Our results show that high error rates and high presentation speeds reduce the potential benefit of subtitles” [9].

The results of a study published in 2023 by Malakul et al., however, suggest that automated subtitles have a more significant positive impact on the productivity of assimilating educational videos compared to edited subtitles:

“While subtitles are considered a primary learning support tool for people who cannot understand video narration in foreign languages, recent advances in artificial intelligence (AI) technologies have played a pivotal role in automatic subtitling on online video platforms such as YouTube. According to the features on YouTube, the auto caption and auto-translation on the YouTube video player allows learners to access the subtitles freely” [10].

Materials and Methods

We conducted a study on the translation of popular science audiovisual content from English into Russian. Translating audiovisual content between these languages presents several challenges due to significant differences in speech rate and the shares of semantic and visual components. We used TED Talks popular science lectures. The collection of TED Talks videos is freely accessible. The lectures cover a wide range of topics, addressing current research, and the speakers present the content in a manner understandable to the general public. TED Talks videos are

also available on YouTube, enabling the use of the Yandex machine translation service for automated subtitle translation.

We selected the videos based on the following criteria to evaluate the quality of automated subtitle translation:

1. Source language: English.
2. A transcript of the original language is available.
3. The lectures cover a wide range of subjects.
4. Each video is 10-12 min. long.
5. The video includes specialized vocabulary and/or n-grams, which pose significant challenges for automatic translation systems.

With these criteria, we selected the following videos: “Does AI actually understand us?”, “For the love of birds”, “How to buy happiness”, “How video games can level up the way you learn” and “Why people and AI make good business partners”. The subjects are ecology and citizen science, advanced information technologies for business, mathematical linguistics and artificial intelligence, cognitive science and computer games, and consumer behavior research.

To assess the quality of automatic subtitle translation, we employed traditional fuzzy search methods: the Levenshtein editing distance and the BLEU metric. These methods evaluate similarities between text strings [12–13]. The Levenshtein distance is a metric used to measure the minimum number of single-character edits (insertions, deletions, or substitutions) required to change one string into another. The BLEU metric compares the machine-generated translation with one or more reference translations based on n-gram precision and brevity penalty.

We conducted a comparison between the automatic translation by the Yandex MT service and the translation performed by a professional translator.

We used the Tilde Custom Machine Translation online calculator and Python code. Python provides libraries for quick and easy data analysis. The IDE was Jupyter Notebook. The pandas library was used to process tables. The texts were normalized using the NLTK (Natural Language Toolkit) library. The Levenshtein library measured the Levenshtein editing distance. We also utilized the embedded statistics module with mathematical functions designed to handle variables of real type.

Results and Discussion

The Levenshtein distance and BLEU metrics for each video are presented in Table 1.

The results can be interpreted as follows:

1. The shorter the Levenshtein distance, the higher the quality of machine translation.

2. The BLEU metric evaluates translation quality using a standardized 0…100 scale. It considers not only individual words but also n-grams [10].

Table 1

Levenshtein distances and BLEU metrics

Video	Subject	Average Levenshtein distance	BLEU
For the love of birds	Ecology and citizen science	20	68.20
How to Buy Happiness	Consumer behavior research	12	76.67
Why People and AI Make Good Business Partners	Advanced information technologies for business	14	77.42
How Video Games Can Level up the Way You Learn	Cognitive science and computer games	11	80.67
Does AI Actually Understand Us	Mathematical linguistics and artificial intelligence	9	83.19

The results show that machine translation performs best on texts directly or indirectly related to computer technology. This is because modern machine translation systems employ neural networks trained on publicly available data sources. For instance, Google provides Google Dataset Search, a specialized search engine for locating freely available parallel texts. It would be reasonable to assume that availability and popularity are two crucial factors in selecting training datasets. Information technology is one of the most discussed and fastest-growing industries in the world. The majority of IT news and training content is published in English. Moreover, according to reports from the Yandex blog, IT is the most popular domain for English-to-Russian translation using the Yandex.Translate service. It accounts for about 80% of user requests [13].

The poorest result was observed in the translation of the video concerning social and environmental issues. Environmental subjects are equally popular compared to IT, although there are notable differences between the two. Translation errors in environmental content occur not only because many environmental terms are context-dependent.

Automatic subtitle translation inherently cannot account for the video content, resulting in significant errors. For example, in the video, the speaker refers to penguins using the general term “penguins”, and vaguely refers to their habitat as “ice caps”. Yet the video sequence shows the emperor penguin (*Aptenodytes forsteri*), a specific species with a specific habitat. The issue arises because there are multiple species of penguins inhabiting Antarctica, and “ice caps,” directly translated by machines as “ледяные шапки” in Russian, also exist in other locations. Besides, ice caps are not the only habitat for penguins. Some species live in the tropics. The speaker’s imprecise presentation necessitates clarification and fact-checking during translation, tasks that only a human translator can perform.

In the above example, there is also a morphological error, which is present in the original transcript as well. The demonstrative pronoun “this” in the singular is used with “penguins,” a plural noun. Such errors often find their way into the translated text, significantly diminishing its quality.

Human and Machine Subtitle Translation

Our comparison of translations provided by the Yandex machine translation service and human translators reveals that both machines and humans can make similar mistakes. However, human translation consistently demonstrates significantly higher quality.

The most common machine translation errors are lexical: word-for-word translation, lexical incongruity, and incorrect or inappropriate use of certain words within context. Regarding n-grams, machines can accurately translate only common or standardized multiword expressions. If the speaker introduces something novel, neural networks may struggle to contextualize metaphors appropriately. The machine also often fails to correctly recognize proper names (in this study, they are names of charity initiatives, companies, applications, and games). This can be explained by the fact that these names either did not appear at all or appeared very infrequently in the training dataset.

Sometimes we encountered incorrect verb conjugations. In one of the videos, the sentence "…they run over to Starbucks…" was translated by the neural network as "… и они побежат в Старбакс…". The perfect verb "побежать" in the 3rd person plural future tense should take the form "побегут". The verb "побежат" is a morphological error.

Another common morphological and semantic error is incorrectly indicating the gender of a person whose speech is indirectly conveyed. The neural network relies on the distinctive features of the speaker's voice. If the speaker is a man, the verb endings in Russian will correspond to the masculine gender in conjugation; if the speaker is a woman, they will correspond to the feminine gender [14]. It is more complicated with indirect speech because the machine can rely on the context only.

Automated translation is unable to produce unique text; instead, based on statistics, the system selects the most commonly used translation equivalent, thereby impacting the text quality. The human translator uses synonyms to avoid repetitions. For example, "citizen science" can be translated as "научное волонтерство", "общественная наука", "любительская наука". The adverb "so" is translated not only as "итак", but also as "так", "именно", "таким образом", "действительно", "следовательно", and so on.

In addition, both machine and human translators have difficulties with syntactic transformations. The machine is currently unable to translate complex syntax. The word order in Russian is quite flexible, but it depends on both grammar rules and the speaker's intention when arranging words in a sentence. Sometimes to convey the meaning with greater accuracy, the sentence structure should be rearranged. For example, to emphasize intonational pauses, and accents, or adapt the author's writing style, the word order in a sentence in the target language may differ (we consider the En-Ru translation pair). There is also an issue with punctuation (quotation marks, commas, dashes, etc.) For example, in Russian, a dash is placed

between the subject and the predicate in place of the missing conjunction, if the subject and predicate are expressed by nouns in the nominative case [1]. In English, this role is performed by the copula, the "to be" binding verb. If the original sentence is syntactically complex and lacks punctuation marks, such as a dash, it may also be omitted in the translation, although this variation is permissible in such cases. Let us consider and compare the examples presented in Table 2.

Table 2

Examples of Syntax Transformations

Original	Machine translation
The children indeed are our future.	Дети действительно – наше будущее.
But this feather is more than just that.	Но это перо – нечто большее, чем просто перо.
This is a feather from one of the most beautiful birds we have in Kenya…	Это перо одной из самых красивых птиц, обитающих у нас в Кении…

As can be seen, the machine can transform sentences in accordance with the codified syntax rules of the Russian language. It is worth noting the sentence "This is a feather from one of the most beautiful birds we have in Kenya...", translated by the machine as "Это перо одной из самых красивых птиц, обитающих у нас в Кении". We cannot say the translation is completely incorrect. Still, the speaker adds a pause after "this", so an intonational hyphen is expected: "Это – перо одной из самых красивых птиц в Кении…".

Machine translation lacks hyphens in sound imitations or long sounds. For example, the long "O" in machine translation is "Ooooooo", while the human version is "O-o-o-o-o-o". Such cases affect the overall reading experience since the text style suffers.

It is also important to note that machine translation systems do not recognize erratives, which are words or expressions deliberately distorted by native speakers. Currently, attempting to translate an errative may result in transliteration because erratives, being unique expressions, lack dictionary equivalents. Accidental errors, such as typos, are typically translated through transliteration unless the autocorrection system suggests a correction during the original text input. In the vast majority of cases, neural networks can independently select the most appropriate word by considering the semantic relationships with other words in the sentence. For example, Yandex.Translate still translates the misspelled word "yoir" as "твой", "misunderstanding" as "непонимание", and "beografical" as "биографический".

Let us consider a short sentence from one of the videos: Let"s consider a short sentence from one of the videos: "With me here today I brought something beautiful", and deliberately distort it to "Wiz me here tuday I brought somifing beautifule". This results in an errative, and we would expect the translation to also be an errative to convey the original meaning accurately. In reality, when translated, the distorted sentence will be normalized to "Приведи меня сюда, сегодня я принес кое-что очень красивое", since the user has no way to tell the system to keep erratives. The

reason lies is inherent to machine translation: speech is first recognized, then transformed into text, and finally translated, following the principles described above. Computational graphs in hybrid speech recognition systems, which combine Markov models and neural networks in the classification process, currently cannot recognize words that are not in the dictionary. This limitation arises because these models are based on the maximum likelihood criterion. Translating abstract language units is one of the most difficult tasks for machine translation [15], [16].

A distinctive feature of the Yandex automatic subtitle translation service is that the system does not display subtitles denoting sound effects (e.g., applause and laughter). Most likely, the neural network recognizes such sounds as noise and removes them at the pre-processing stage. Note that YouTube's neural network can recognize applause, music, and crying. However, it happens only when the sound is not in the background (not overlapped by human speech). If applause, crying, or laughter is heard during the speaker's speech and the sound itself is relatively subdued, in the vast majority of cases, no corresponding subtitle is generated.

Conclusions

Machine translation of subtitles typically achieves a quality score of 68 to 83 on the BLEU metric, which is adequate for initial familiarization with the video. From a professional translation perspective, such a result is unsatisfactory, necessitating a mandatory post-editing stage when using machine translation systems at their current stage of development.

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Сведения об авторах

ЭГАМБЕРДИЕВА
Элина Джамбулатовна
e-mail: *elega.work@gmail.com*

Бакалавр по направлению «Лингвистика», выпускница кафедры иностранных языков Государственного университета аэрокосмического приборостроения (Санкт-Петербург, Российская Федерация)

About the authors

Elina J. EGAMBERDIEVA
e-mail: *elega.work@gmail.com*

BA (Linguistics), Dept. of Foreign Languages, State University of Aerospace Instrumentation (Saint Petersburg, Russian Federation). ORCID: https://orcid.org/0009-0003-0115-4837

ЧИХАНОВА Марина Анатольевна
e-mail: *chikhanova.m.a@gmail.com*

Кандидат филологических наук, доцент, заведующая кафедрой иностранных языков Государственного университета аэрокосмического приборостроения (Санкт-Петербург, Российская Федерация)

СТЕПАНОВА Мария Михайловна
e-mail: *m.stepanova@odin.mgimo.ru*

Кандидат педагогических наук, доцент кафедры английского языка факультета финансовой экономики Московского государственного института международных отношений Министерства иностранных дел Российской Федерации, Одинцовский филиал (Одинцово, Московская обл., Российская Федерация)

ТРОИЦКИЙ Дмитрий Игоревич
e-mail: *dtroitsky@gmail.com*

Кандидат технических наук, доцент, доцент кафедры иностранных языков Государственного университета аэрокосмического приборостроения (Санкт-Петербург, Российская Федерация)

Marina A. CHIKHANOVA
e-mail: *chikhanova.m.a@gmail.com*

Cand. Sc. (Linguistics), Associate Professor, Head of the Dept. of Foreign Languages, State University of Aerospace Instrumentation (Saint Petersburg, Russian Federation). ORCID: https://orcid.org/0009-0007-2349-7848

Maria M. STEPANOVA
e-mail: *m.stepanova@odin.mgimo.ru*

Cand. Sc. (Pedagogy), Associate Professor of English Language Department, Moscow State Institute of International Relations of the Ministry of Foreign Affairs of the Russian Federation, Odintsovo Branch (Odintsovo, Moscow Region, Russian Federation). ORCID: https://orcid.org/0000-0003-0444-8155

Dmitry I. TROITSKY
e-mail: *dtroitsky@gmail.com*

PhD (Engineering), Associate Professor, Dept. of Foreign Languages, State University of Aerospace Instrumentation (Saint Petersburg, Russian Federation). ORCID: https://orcid.org/0000-0002-1675-6377

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