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STROJOVÉ PŘEKLADY ODBORNÝCH TEXTŮ

ONLINE MACHINE TRANSLATION OF TECHNICAL TEXTS

BAKALÁŘSKÁ PRÁCE

BACHELOR'S THESIS

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Online machine translation of technical texts

INSTRUCTION:

The aim of the bachelor paper is to define and describe machine translation systems with a focus on available online translators, including their development, current status and methods of evaluating the quality of machine translation outputs.

RECOMMENDED LITERATURE:

HUTCHINS, J. (2012). Historical sketch of machine translation in Eastern and Central Europe. Hamburg: Crosslingual Language Technology in Service of an Integrated Multilingual Europe.

POIBEAU, T. (2017). Machine Translation. London, Cambridge: MITT Press

OKPOR, M. (2014). Machine Translation Approaches: Issues and Challenges. International Journal of Computer Science Issues, Vol. 11, Issue 5. No. 2, 159-165.

ZEHNALOVÁ, J. et al. (2015). Kvalita a hodnocení překladu: Modely a aplikace. Olomouc: Univerzita Palackého v Olomouci

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Subject Council chairman

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Abstrakt

Tato bakalářská práce se zabývá a následně testuje způsoby pro hodnocení dvou strojových překladačů, a to od firmy Google a Microsoft. Na základě stanovených kritérií hodnotí jejich chybovost. Při hodnocení překladačů se práce zaměřuje nejen na to, zdali daný překladač dokázal přeložit soubor textů správně pravopisně a stylisticky, ale i zda odborná terminologie spolu s myšlenkou věty odpovídá původnímu textu. Na závěr ze získaných dat chybovosti je možné usoudit, pro jaké využití bude daný překladač způsobilejší.

Abstract

This bachelor thesis discusses and then tests the methods of evaluating two machine translators, namely from Google and Microsoft. Based on established criteria, from data received each translator is assigned their error rate. When evaluating translators, the work focuses not only on whether the translator was able to translate a set of texts correctly (spelling, stylistics), but also whether the professional terminology together with the idea behind the sentence corresponds to the original text. In conclusion, the obtained error rate data enable to assess the given translators for suitability in terms of their usage.

Key Words

Mechanical Translation, Translators, Translation of technical Language, Mechanical Translators

JUŘÍK, Michal. *Strojové překlady odborných textů.* Brno, 2022. Dostupné také z: https://www.vutbr.cz/studenti/zav-prace/detail/142602. Bakalářská práce. Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií, Ústav jazyků. Vedoucí práce Dagmar Šťastná.

Prohlášení

Prohlašuji, že bakalářskou práci na téma Strojové překlady odborných textů jsem vypracoval samostatně pod vedením vedoucího bakalářské práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

V Brně dne 30.5.2022

.....

Michal Juřík

PODĚKOVÁNÍ

Děkuji tímto Mgr. Bc. Dagmar Šťastné za cenné připomínky a rady, které mi poskýtáte při vypracování závěrečné práce.

1 Introduction

This research is trying to determine which online machine translator among commonly accessible translators has better use for different professional fields and to what degree they can accomplish successful translations.

The study briefly looks at how machine translation was created. What was machine translators main use, and how quickly they developed and improved. The main aim for this research can be the evaluation of the translated texts. In what way can they be evaluated and how should be different findings rated to form a score. The main goal may be to set definitions of how the practical research can be executed. As two translators can be compared, suitable methods that may be available for finding a "better" translator may be listed.

The method that can be preferred by the author is be selected and used to see the accuracy of the translators, a degree they differ in, and what they are more suitable for in terms of context, grammar, and stylistics. Due to the fact that the translators used are fully automatic it is possible that some evaluation methods may not be able to define translators to such a detail that can distinguish these translators and show in which ways they are better and more suitable to different field of texts.

If both translators do not preform identically, this research may be able to select the one that is more suitable for different field of texts. If this situation occurs, to have finding with more diverse results additional text may be put in use for finding more diversities. This additional text may be put in use only if evaluation of original first texts cannot be able to provide sufficient information about differences between two chosen translators. This should provide a very accurate depiction of which translator can be the most useful.

2 Theoretical Part

2.1 Machine translation

Translation relates to many complex questions concerning linguistics, philosophy even psychology.

> Translation is connected with a large number of questions dealing with linguistics, but also psychology or even philosophy when the nature of meaning is at stake. (Poibeau, 2017:15).

Instead of addressing these highly complex questions, it is vital for characterization of a "good" translation to retain same context and meaning as the original author intended. Before addressing machine translations, it is important to understand the notion of translation. Thierry Poibeau describes criteria for translations as:

> Translation should be focused to remain faithful to the original text, respect its main characteristics, tone style, the details of the ideas as well as its overall structure. Translation should be easy to read in the target language. Translated text should be linguistically correct, which means that subtle process of reformulation must be used. Ideally reader should not realize that he is reading a translation. (Poibeau, 2017:16).

The translator must perfectly understand the text they have to translate, but also even better knowledge of the target language. It is important to understand the context in which the translation may be used. Depending on if the text is technical, it may not be translated same way as literary texts. Tone and style of the text are highly subjective notions that are largely related to the language under consideration.

2.1.1 Brief history of machine translation

In Hutchins and Somers's research (1992), George Artsrouni issued a patent for the first storage device capable to find translation of the selected word in other languages in 1933 and demonstrated it in 1937. Along with Artsrouni, Petr Smirnov-Troyanskii issued a patent for a similar device but with greater significance. Trybanski's idea was based on three stages of mechanical translation. The first stage was be done by the editor using only the source language to transfer them into their base forms and syntactic functions. The second stage

consisted of transforming the base forms into the target language, followed by the final stage of the second editor with knowledge of only the target language converts base forms of target language into normal forms of the target language.

Few years later, the first discussions about the usage of computers for translations started. After 1949, the research started at many universities in United States. In 1951, Yehoshua Bar-Hillel was appointed the first full-time researcher for machine translation. Based on Bar-Hillel's research, it was obvious that fully automatic translation would not be possible without a long-term research and human assistance was essential for text preparation or the output revision.

The project in which Georgetown University Leon Dostert with collaboration with IBM in 1954 resulted in a public demonstration of machine translation of Russian language into English, this demonstration resulted in the large-scale funding of Machine translation in the USA. In the following years, the machine translation went through modernization as the technology at the time was the main problem that the researchers had to solve. In 1958, IBM developed system for US Air Force. The system was barely intelligible and crude. Further development was based on a software form of the translator as computer-based dictionaries became more common.

Until 1976, the translators were intended mostly for government use. Later, commercial systems started to appear, the most successful translator called Systran initially used as ' direct translation ' system and its oldest version translated over a hundred thousand pages a year. After 1980, although most machine translators were still translating in crude translations, economically viable results for a design for these machines started to appear achieved by a microcomputer system integration rather than use of a mainframe systems. These microcomputer systems were mostly marketed as a computer aid for the translators. The first commercially available Machine translators were available in two options, as a service and as a computer aid for the translators. Service option turned nonprofitable and unpopular.

2.1.2 Basic definition of MT, approaches to MT

As W.John Hutchins states in his study on machine translations history:

> The term 'machine translation' (MT) refers to computerized systems responsible for the production of translations with or without human assistance. (Hutchins, 1995:431).

This definition of machine translation is clear on how machine translations are produced. Machine translations were produced by three main methods.

The first method is rule-based and uses traditional rule-based grammatical categories and features. To provide system with these predefined rules, a human translator had to create a database for these types of systems. This process provides the machine translator with set of linguistic rules of different kinds, which were than used during the translation.

The second method is corpus-based. This method consists of a corpus with translation examples. In the same ideology is an example-based method and nether one of these methods used syntactic or semantic rules.

The final and most advanced method is neural machine translation, and this method is based on neural networks that are trained to recognize grammatical and lexical parts. This method heavily dependent on amount of training data. The translators using this methodology achieved fluency at the cost of adequacy.

2.1.3 Neural machine translation (NMT)

Poibeau describes neural machine translation as:

> With deep learning, the simultaneous management of various types of information enables more reliable decision making. These models are said to be hierarchical, but they are in fact multidimensional, meaning that each element (word, phrase, etc.) is placed within a richer context. (Poibeau, 2017:121).

Furthermore, Poibeau explains that this method of a translation provides an interesting approach for a translation where word translation does not correspond to different languages and can be expressed by a group of words depending on the context.

The method of neural machine translation depending on the sample of data or references provided to the system improves of its learning capabilities exponentially.

2.2 Online machine translators

The ability to quickly translate texts to different languages was very useful mainly for military purposes from the beginning. Only later when the translators themselves became publicly accessible they started to be more used for sharing people's knowledge.

By the end of 1940s, Britain tried to create computer translators. This system worked on principal that if the system found an unknown word it would delete the last letter from the given word and search in the database for a potential match. This process was repeated until the system found a translation for the original word. In later years, there were improvements, but the machines were still generally found having too many boundaries that prevented them from the proper use, mainly the fact that different languages are too vague to achieve correct and contextual translation. One of the designs of the machine translators was a system based on example-based translations with pre-defined examples. The original text, which the device compared with a predetermined examples or fragments of already known translations, would segment the sentences by words or phrases and then proceeded to translate them. Resulting in a translation in fragment, just parts of the sentence at a time. This kind of a method is not efficient because the context of the sentence can be easily lost due to the possibility of wrong fragments being used.

Before the year 1990, many improved variations of systems were created. The main downside was their reliance on a mainframe technology. By the 2000s, computers that were able to use these systems became available to the public.

Today companies provide commercially accessible translators such as Microsoft, Google. For the purposes of this thesis were chosen two online machine translators that are from a rival company, and both are commonly accessible. Because both companies used and use old types of translations and use the same type of a method for translations and since 2016 both use their own version of Neural Machine Translation.

2.2.1 Microsoft Translator

The first online machine translator is Microsoft Translator. This translator has many functions that are available on all platforms of Windows, IOS, and on Google play.

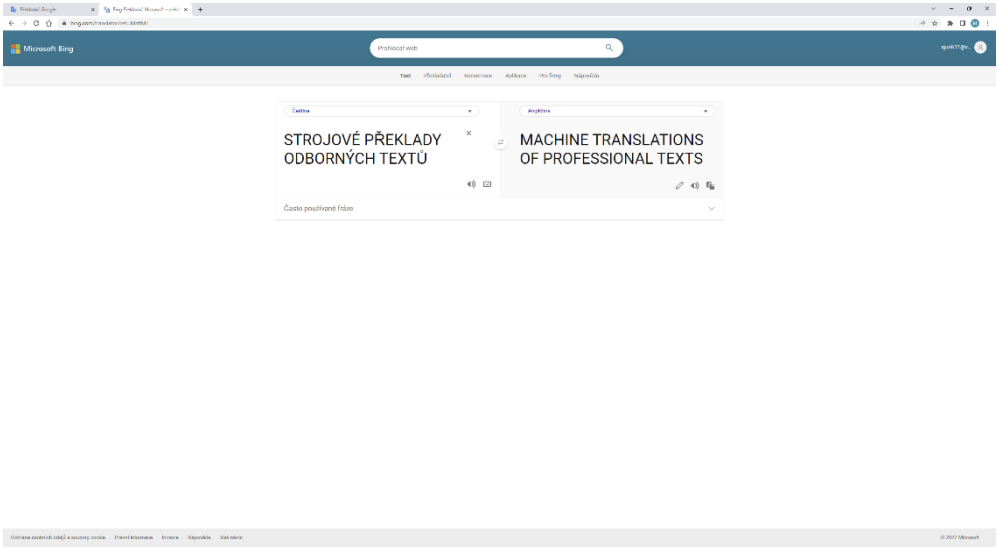


Figure 1. *Microsoft Translator interface [11].*

One of the first features is ability to translate text and voice conversations via live chat that users can connect to with QR code. All messages in this chat room can be translated to you your selected language user wants to use, for example the user's main language. This feature can be very handy on convention centers and multilingual presentations.

The second feature the Microsoft Translator has is Voice translation. The Voice translations has two modes one for a single microphone and the other split-screen- translation. Single microphone enables user to translated text using microphone to for example to be able to as for direction in foreign country. Single microphone feature works primarily while online with limited usability for longer sentences when offline. The Split-screen feature splits the screen into two parts and on each part, you can select different language. Then the user can communicate with the person speaking the second selected language and the Microsoft Translator first records your message to translate it to the second language and play it from speakers. This feature can be very useful when traveling or when the user of this app is in a situation in which he cannot speak the second language, but also is in hurry and does not have time to look up long phrases to express what he wants to ask about.

The third feature is Text translation, and this feature works in both online and offline mode. The Microsoft Translator can translate text in over 70 languages. Enables user to safe

his frequently used translated phrases or share them via text, email, or social media. For translated words you can with one click of button look up alternate translations and meaning of a word to be able to find the best translation to express yourself.

The fourth feature is Camera, this feature can translate text from cameras or photos. This feature works offline and online and is most used for translating signs on streets or menus in restaurants while traveling abroad which were the main targeting areas for this feature.

The last feature of this online translator is Phrasebook. Phrases for travelling or business are always available, because over 200 phrases are included in the app without any additional downloads. These phrases are verified translation for travelling, direction, lodging, dining, and more topics. With the Pronunciation guides with three speeds to help you learn how to pronounce the important phrases. The feature of different speeds of the pronunciation of these phrases makes learning the phases very easy and fast.

After all these features, Microsoft Translator surprises with its accessibility. The Microsoft Translator is integrated in products including Bing, Microsoft Office, SharePoint, Microsoft Edge, Skype, Yammer, Internet Explorer, and many others. Especially the integration in Microsoft Word makes this translator viable and useful in everyday usage.

Microsoft Translator does not stop here, Microsoft Translator offers three special plans with specific tools for Personal use, Education, Business, and all of them are offered for free. The Personal use has been already described in features of this online machine translator. Business uses of Microsoft Translator can be seen in Customer support, as the integrate translation in customer support workflow. To achieve improvement in internal communications among global workforce, a comprehensive analysis of multi-lingual business intelligence of a company must be conducted.

Microsoft translator for the education purposes can be exploited, for example, in lectures and presentations. Microsoft Translator can be used for translating and caption live presentation and engage students who are non-native or have learning disabilities. The feature of live captions during a presentation is already integrated inside Microsoft Office package and can be activated in seconds.

Microsoft Translator uses the neural machine translation since 2016. The neural machine translation is used to find the best context for the translated word. Simplified explanation of this method starts by giving each word 500-dimension vector to represent the

word which is than encoded by the first neural layer into 1000-dimension vector to represent the context of the word in the sentence. Final matrix uses software algorithms to define which word from the original sentence can be translated next. Lastly, the decoder translates the word in the context of the full sentence into the most appropriate target language equivalent. After the original word is translated, the algorithm calculates which next word from the source text can be translated.

2.2.2 Google Translate

The second online machine translator that is part of this thesis is Google Translate. The amount of languages Google Translate supports is over 100 languages, but some of these languages, unlike in Microsoft Translator, are not available for all functions including offline mode. The Google Translate incorporates six main features.

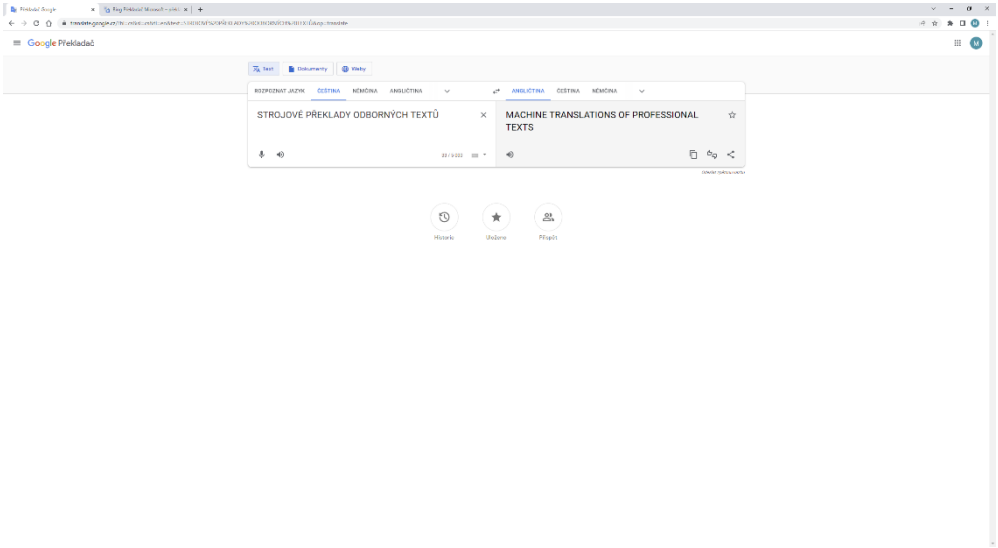


Figure 2 Google Translate interface [14]

The first feature is characterized by typical keyboard input that can be translated from one of the 100 languages in this translator's database into languages that are included within it. The text translations are available also for documents and text files that can be uploaded into the translator's window and proceeded to be translated.

The second feature is Camera, which is claimed to work only on mobile phones and can translate text in real time with the camera capturing the text that is intended to be translated.

The third feature, which is similar to the Camera, is Snap designed to translate photos rather than real time translations of text. This feature is intended for images of text. Limitations of the feature Camera being available only on mobile phones are not applied to Snap feature. The Snap can be used in browsers or any other software using or supporting Google Translate.

The fourth feature is called Talk and supports bilingual conversations. This feature plays audio of the translation and helps the user to learn how to pronounce different words or phrases in a foreign language translated by the user. This feature is not separated into chat sections and is part of the Text feature. There for every translated phrase would have to be copied and then paste in desired conversations.

The fifth feature is Offline. The ability to use Google Translator and some of its feature without any internet access enables the user to us the translate function any time. This feature does not support all languages and cannot be used in all functions. Although most used languages are supported in all functions in offline mode, some languages can be unavailable.

The sixth feature is Write and allows a user to scan drawn letters or characters on a touchpad or mobile screen, and then proceed to translate them into a desired language or just convert them into a plain text. This feature can be very useful for using tablets or mobile phones for notes without losing the ability to use cursive. When it comes to the accessibility, Google Translate is available on browsers, Google Docs, Google Sheets, and many other Google Drive products. The option to download this translator on android but still being dependent on the internet connection, is the main disadvantage of Google Translate. Google translate uses neural machine translation in a similar way as Microsoft does. Google translate also uses neural machine translation as the prediction algorithm for the translation of the original word in the target language.

2.3 Evaluation of machine

The evaluation of machines is the subject of the very intensive research since 1990. Since mechanical translators do not have the subjectivity and the user's point of view, their evaluation has nothing to do with literary translations.

One of the ways how to evaluate the translators, is to translate a text by a professional human than by machine translators. These translations are then given to the analysts who are then asked questions about the article to find out if the context has remained. This evaluation is also called "direct comparability".

> This test was initially named "direct comparability" because it was supposed to allow for a direct comparison of different systems from different source languages. (Poibeau, 2017:132).

One of the most difficult and expensive ways to evaluate the translator is the "evaluation panel". This is the method that translates the original text to different languages, which are than viewed by a human who evaluates its lexical, grammatical, semantic, and stylistic aspects. Due to the subjectivity of the human rating, the translated text evaluations are inaccurate.

> Evaluation Panel. The most obvious way to evaluate the quality of translations is to appeal to human judgment, notwithstanding the great degree of subjectivity inherent in human judgment. (Poibeau, 2017:132).

Adequacy and Fluency method aim at precision of retaining the context of the translations and the forms of the sentences. This method is faster and much cheaper than the previous methods, but the subjectivity of the expert rating the translation still varies. This method consists of a monolingual English speaker that decides the degree to which information in professional translation can be found in machine translation output.

> In an adequacy evaluation, literate, monolingual English speakers make judgments determining the degree to which the information in a professional translation can be found in an MT (or control) output of the same text. (Poibeau, 2017:133).

After realization that no automatic translator may be capable of producing a perfect translation, it was decided to use machine translators to just help human translators to achieve

desired quality. This proven to be useful for less skilled human translators rather than experts. These versions were made with interaction of the user in mind. Three measures were used: comprehension, adequacy, and fluency of the final translated text.

> In the mid-1990s, three measures were mainly used for evaluation: comprehension, adequacy, and fluency of the generated text. These three measures were interesting but relied largely on human judgment, which is known to be costly and partially inconsistent. (Poibeau, 2017:134).

Automatic Measures are mathematically based and are very complicated. The automatic evaluation wants to answer a simple question if the translation is "good" but it comes to the conclusion in very complex way. The principles of the Bilingual Evaluation Understudy, or BLEU, the score system is simple, compare a reference translation with an automatically produced translation (Papineni et al., 2002).

> The idea is to compare a reference translation TRef with an automatically produced translation TAuto . The BLEU score is calculated by truncating TRef and TAuto into segments of length 1 to n, called n-grams (it is generally assumed that the most reliable result is obtained when n = 4) and by comparing the number of segments shared between TRef and TAuto . (Poibeau, 2017:134).

If two texts are being compared by BLEU and all of their segments are identical the score is 1, on the other hand if not a single segment is similar in these texts than the score may be 0. Basically, the closer TAuto is to the reference more of the segments can be similar in these texts.

The National Institute of Standards and Technology is an organization organizing evaluation campaigns and developed the NIST score at the same time as BLEU. The key differences lie in the fact that NIST includes the informativeness factor. The informativeness factor gives parts of the translations that are not being commonly used, higher weight the less is the part of the translation is used.

> American organization organizing evaluation campaigns in various fields, developed the NIST score during the same period as the BLEU score (Doddington, 2002). (Poibeau, 2017:135).

METEOR score has been developed more recently and accounts for semantics. METEOR is based on identification of semantically "full" words shared between the text to be evaluated and reference.

> The idea is then to identify longer sequences of text around these full words that are shared between the two texts. As with other measures, the greater the number of shared segments, and the longer these segments are, the closer the METEOR score will be to 1. Poibeau, 2017:135).

When words are translated, they can be replaced by their stem or their lemma or even synonyms, this if viable for achieving more reliable and robust method. This is the main reason why METEOR is not available for all languages due to the number of resources needed to realize this method.

The authors of METEOR report that results better correlate to human evaluation than the BLEU or NIST scores. However, METEOR is a lot more difficult to operate and the different options make the results more difficult to interpret and compare over time. Therefore, METEOR is less frequently used, while the most used score out of these three is BLEU despite its limitations.

3 Methodology

The study was carried out on a designed corpus, incorporating extracts of teaching scripts. The study consists of the human translator checking translations of each machine translators for errors. The main concern of this study was the terminology used by the translators during translation.

The corpus consists of three investigated texts, "Multimédia", "Návrh systémů s digitálními integrovanými obvody a mikroprocesory pro integrovanou výuku VUT a VŠB-TUO." and "Elektronické součástky sbírka příkladů". The texts used in the translations are scientific and descriptive in nature with specific terminology, specifically from the areas of IT and electronics. The scrips summed up to total of 2212 source Czech words.

The scripts are referred to with abbreviations to improve the readability of the tables: "Multimédia" is referred to as „M ".

“Návrh systémů s digitálními integrovanými obvody a mikroprocesory pro integrovanou výuku VUT a VŠB – TUO.” as NSD, and finally

the “Elektronické součástky sbírka příkladů” as ESS.

	M	NSD	ESS
Original characters	8268	6001	1231

Table 3.1 *Individual script size in character before translation*

The translations are firstly check for errors at the grammatical and lexical levels. After the initial check of errors, the technical language used by the translator is check for its correctness. Finally, the terminology is analyzed to determine whether the terminology is used correctly.

3.1 Hypothesis

The first hypothesis is that the translators should translate the texts in coherent target language based on the Neural Machine translation that these translators use.

The second hypothesis is that the translators mostly cause grammatical errors, due to the specific context needed for the original texts.

The third hypothesis is that Microsoft Translator is used in larger scale compared to the Google Translate, which implies that the Microsoft Translator is more capable given its larger sample of texts and there for should be superior in the terminology and understanding of meanings in technical language. Meanings in relation to the context and most suitable translation to be used within the context.

3.2 Evaluation model

Each of the translated section receives a marking depending on the errors made by the translators, marking of the errors in format:

X-L, X-G, X-L

Where the X stands for the translator that made the error.

Microsoft Translator – MST

Google Translate – GT

3.2.1 Lexical errors

These errors for purposes of this thesis are concerning the terminology, proper nouns, phrasal verbs, false friends, idioms, etc. The lexical errors are marked as X-L

3.2.2 Grammatical errors

The grammatical errors made by the translator include morphology, passive, missing prepositions etc. The grammatical errors are marked as X-G

3.2.3 Translation errors

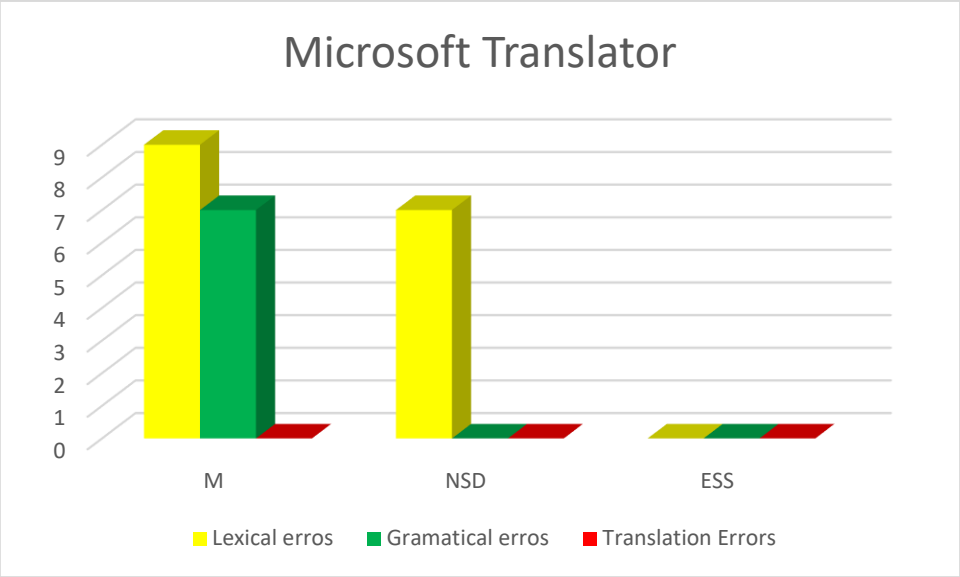
The translation errors consist of non-preformed translation to the target language and wrong translation excluding terminology from fields of IT or electronics. The translation errors are marked as X-T

4 Procedure

The first step of analysis is translating all the original sections via each translator. And putting them into tables for easier comparison. The second step of the analysis was to identify the errors made by the translators and have the errors marked in tables with their appropriate tags. The third step of analysis is to create graphs from gathered data and to find the first conclusion to the hypothesis about the error rate of the translators. The fourth step of analysis is comparison of the performance of each translator to find the superior translator. The final step of analysis was creation of a conclusion based on the data gathered from the analysis.

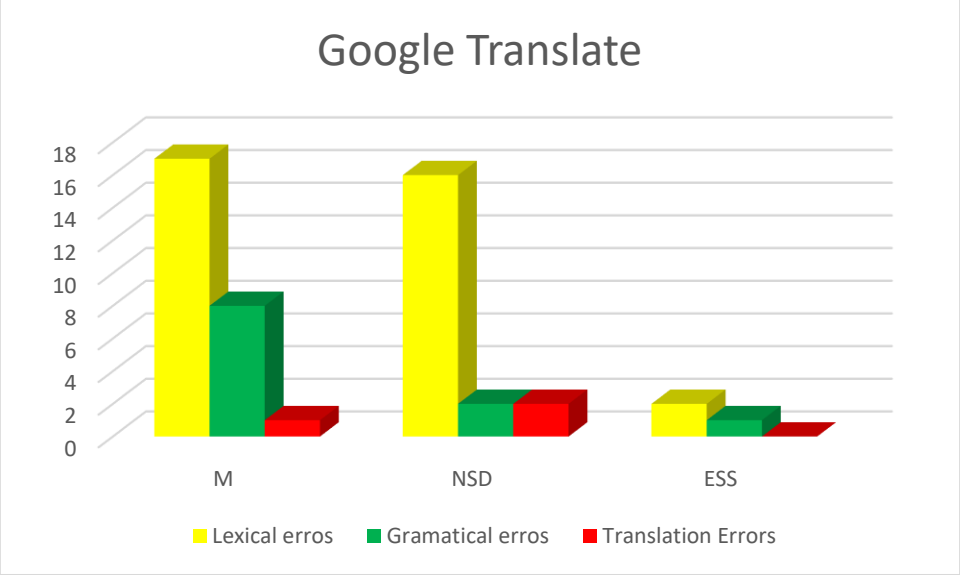
5 Research findings

From the analysis of all the translated texts each of the translators was assigned with its errors and for clear representation of the error rate of each translator put into a graph showing what is the error rate for the translator in each of the translated scrips. The Graph 5.1 depicts error rate of the Microsoft Translator for each one of the scrips. An Example of an error made by the Microsoft Translator: From the original text “barvonosných složek “, translation by the Microsoft Translator was “color-bearing.” This translation changes meaning withing the context as “color-bearing” in English language refers rather specifically to machinal bearing in the technical context. The suitable translation which was also applied by the Google Translate is “color components.”



Graph 5.1 *Error rate of the Microsoft translator*

The Graph 5.2 depicts the error rate of the Google Translator, notable there were total of three critical errors that stood out. Consisting of mistranslated words, one of which was kept in Czech language, the next critical error was translated with changed meaning in the target language. The last critical error consisted of strangely skipped section of the translated text leaving out section of translation.

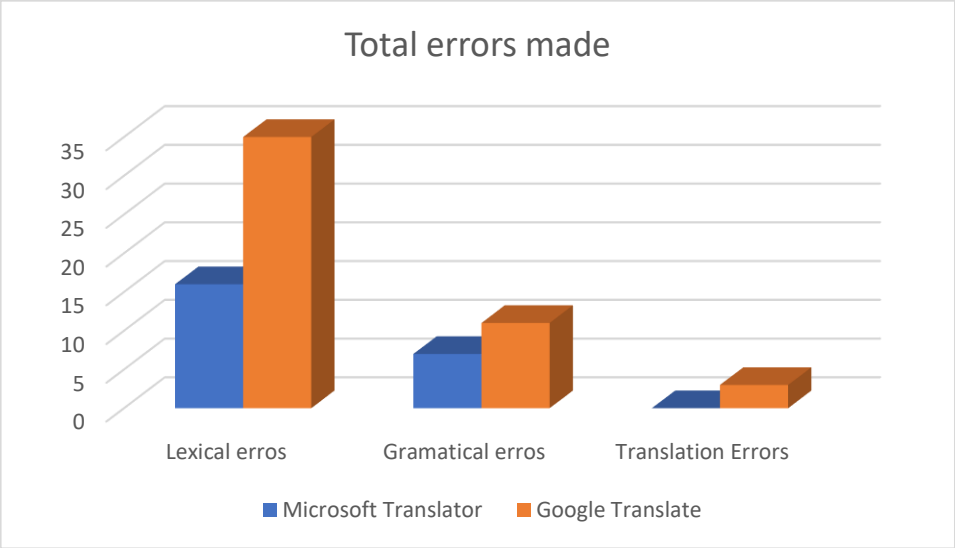


Graph 5.2 *Error rate of the Google translate*

Example of the critical errors made by the Google Translate. Original language: "video MPEG. H.26x apod." was translated as "MPEG video. H.26x apod." where the "apod" was kept in English which is a wrong translation in this case as English language as its own version – "etc." and it was also used by the other Translator. The second critical error was translation of "představují čtveřici." as "represent a quadruple." This choice of translation

changes the meaning into a multiplication instead more suitable translation as “foursome.” The last critical error was translation of “logické funkce uvedeným způsobem.” as “logic function. way.” In this error translator skipped section of translation and ended the sentence twice. The correct translation which was also again used by the other translator was “logic function in this way.”

From the Graph 5.3 we can see what types of errors were created by each translator in the complete analysis and the results point out that the Google Translate is very not suitable for technical text translation due to the high number of errors effecting the context of the translation. On the other hand, the Microsoft Translator also with some errors managed to translate the original texts without mistranslating the original language into the English language.



Graph 5.3 *Total errors made by each translator*

The first hypothesis that the translated text is coherent is confirmed as the translations are understandable and coherent in the target language.

The second hypothesis was disproved, and the most prominent errors were made in the Lexical category.

The third hypothesis was confirmed as the lest errors were indeed made by the Microsoft Translator, confirming that the translator is more capable of translating technical language.

6 Conclusion

To conclude the bachelor's thesis, I would like to mention that it was interesting to delve into the details about the options available for the machine translation. The main received information of the study was that the usability of a translator in use for a technical language is viable if the right translator is used.

The theoretical part mentions development of the translator and their methods of how they translate languages. Then brief introduction of the two translators that are being used in the study. Each translator has their methods on how they translate texts and what type of method they use briefly explained.

In the practical part the text analysis was carried out by very similar translators, the method to evaluate the translators was selected for its suitable parameters for comparison of the two machine translators. Both machine translators translated sections from technical scripts of descriptive nature. The analyzed translated section proved that the machine translators using neural machine translation are capable of coherent and understandable. The second hypothesis made about the machine translators was disproved and showed that most common type of error made by machine translators is lexical error. The third hypothesis was confirmed and the machine translator with the larger sample thanks to its more commonly used nature was indeed the more capable at avoiding the errors and using the neural machine translation to in a way chose a better translation. Even though the hypothesis were confirmed that does not mean that these machine translators are perfect, and they still create errors. The most interesting findings were the critical errors made by the Google translate. However, in terms of the terminology the Microsoft Translator did manage to translate the scripts including technical langue twice as accurately than the Google translate.

In future studies use of a human translators may offer a more accurate indication of how accurate the translations are in comparison with a human translator.

7 Rozšířený abstrakt

Tato anglicky psaná bakalářská práce s názvem Strojové překlady odborných textů se zabývá porovnáním strojových překladačů v překladu technických textů. Jelikož na toto konkrétní téma o porovnání těchto dvou specifických strojových překladačů nebylo vytvořeno mnoho výzkumů, se tato práce snaží alespoň částečně přinést nové poznatky z oblasti porovnání strojových překladačů ve využití u odborných textů. Na začátku této práce byly stanoveny cíle, kterých se mělo v práci dosáhnout. Tyto cíle byly: definovat a popsat systémy strojových překladů, popsat vývoj strojových překladů, současný stav strojových překladů a metody hodnocení kvality strojového překladu, porovnání dvou strojových překladačů, které jsou běžně používány a na závěr vyhodnotit, který z těchto překladačů je vhodnější pro překlad technických textů. Bakalářská práce je rozdělena na krátký abstrakt, prohlášení, obsah, úvod, teoretickou část, metodologie, postup, výsledky výzkumu, závěr, rozšířený abstrakt, seznam zdrojů, seznam tabulek, seznam obrázků, seznam grafů, seznam zkratek a přílohy použité v dokumentu.

V jednostránkovém úvodu je krátce představen cíl práce a stručně popisuje, jakým způsobem bude analýza překladu strojových překladačů probíhat. Základní první metodologie, která bude použita zní tak to: V případě, že oba překladače přeloží vybrané části skript identicky, na základě jejich přesnosti v oblasti technického překladu bude výzkum schopen znázornit přesnost obou překladačů. V případě, že by došlo k tomu, že překladače přeložily části skript identicky využité texty, budou rozšířeny o skripta neobsahující již použitý technický okruh.

Druhou hlavní kapitolou této bakalářské práce je teoretické část. Ta je rozdělena na čtyři podkapitoly. První z nich se zabývá definicí dobrého překladu, dále uvádí historii strojových překladů. V další části první podkapitoly jsou definovány strojové překlady a jejich metody při překladu, dále jsou okrajově definovány způsoby, jakými překládají z originálního jazyka do cílového. V poslední části první podkapitoly jsou definovány neurální strojové překlady, které jsou nejvyspělejší metodou strojového překladu. Druhou podkapitolou teoretické části jsou online strojové překlady. Zde se uvádí historie online strojových překladů a jejich způsob funkčnosti. Dále jsou zde strojové překladače, které budou podrobeny analýze v této práci. První překladač, který je definován je překladač od společnosti Microsoft, jsou zde uvedeny jeho funkce i náhled do jednoho z jeho rozhraní. Dále v této části je uvedeno, od jaké doby Microsoft začal používat metodu neurálních strojových překladů, i způsoby jakými se metody neurálních strojových překladů využívají

právě v aplikaci Microsoft Translator. V závěru této podkapitoly jsou definovány funkce překladače od firmy Google, jeho vlastnosti a funkce, je zde i zmíněno od jaké doby Google Překladač využívá neurální strojové překlady a jakým způsobem je využívá. Obsahem poslední podkapitoly teoretické části jsou hodnocení strojových překladů a také jaké jsou možné způsoby hodnocení kvality překladu, historie způsobů hodnocení strojových překladů a je zde i zmínka o využití těchto metod.

Třetí hlavní kapitola popisuje, jaká z metod byla vybrána pro porovnání dvou vybraných překladačů. Metoda využívá korpusu, ten je navržen autorem této práce a využívá tři výuková skripta. Tyto skripta byly dále přeloženy překladači, každá skripta obsahovala odlišnou odbornou terminologii. V závěru této části je uvedeno, jakým způsobem byl přeložený text překladači analyzován pro tři hlavní skupiny chyb lexikální, gramatické, a překladatelské. V první podkapitole metodologie jsou uvedeny tři autorovi hypotézy. První hypotéza pojednává o tom, že neurální strojové překladače mají dosáhnou srozumitelnému překladu v přeloženém jazyce. Druhá hypotéza pojednává o tom, že nejčastější chyby překladačů budou chyby v gramatické skupině chyb. Třetí hypotéza pojednává o tom, že Microsoft Translator má díky častějšímu využívání na základě integrace do programu Microsoft World dosáhnout menší chybovosti překladu než druhý překladač od firmy Google. V druhé podkapitole metodologie jsou uvedeny kategorie chyb a také jaké typy chyb jednotlivé kategorie obsahují a jakým způsobem jsou tyto chyby vyznačeny v korpusu. Lexikální chyby jsou vyznačovány žlutým zvýrazňovačem, gramatické chyby jsou vyznačené zeleným zvýrazňovačem a poslední typ překladatelské chyby jsou vyznačeny červeným zvýrazňovačem.

Čtvrtá hlavní kapitola uvádí, jaký byl postup při analýze. Prvním krokem bylo přeložit skripta z českého jazyka do anglického jazyka za použití vybraných překladačů. Druhým krokem byla analýza textu i identifikace jednotlivých chyb a označit tyto chyby příslušnou skupinou chyb. Třetím krokem bylo vytvoření grafů pro přehledné znázornění získaných dat o chybovosti obou překladačů. Čtvrtým krokem bylo porovnání chybovosti obou strojových překladačů a na základě hypotézy také zjistit, který z nich byl úspěšnější a vhodnější pro využití pro strojové překlady technických textů. Pátým a také posledním krokem analýzy bylo vytvoření závěru ze získaných dat.

Pátá hlavní kapitola sděluje zjištění během analýzy a uvádí příklady chyb, které strojové překladače vytvořily. Hlavním poznatkem bylo že Google překladač se dopustil tří zásadních chyb překladu, přičemž Microsoft Translator se nedopustil ani jedné zásadní

chyby překladu. Tyto chyby vytvořené Google překladačem obsahovaly nepřeloženou část, chybně přeloženou část a poslední chyba byla úplné vynechání částí z věty, spolu s předčasným a zdvojeným ukončením věty.

V závěru je popsáno celkové shrnutí bakalářské práce, zda se vytvořené hypotézy potvrdily nebo vyvrátily, a také je zde uvedena problematika porovnání dvou překladačů. Jsou zde zmíněny možnosti navyšující přesnost indikace kvality překladů technických textů strojovými překladači.

8 References

Bojar, O. (2012). *Čeština a strojový překlad: Strojový překlad našincům, našinci strojovému překladu.* Praha: Ústav formální a aplikované lingvistiky.

Boušek J., Mojrová B., Kosina P. *Elektronické součástky sbírka příkladů.* BRNO: VUT v Brně, 2015.

ČÍKA, P. *Multimédia*. Multimédia. Brno: Vysoké učení technické v Brně, 2015. ISBN: 978-80-214-5179- 7.

Hutchins, J. W., & Somers, H. L. (1992). *An Introduction to MachineTranslation*. Academic Press.

Hutchins, J. (2012). *Historical sketch of machine translation in Eastern and Central Europe.* Hamburg: Crosslingual Language Technology in service of an integrated multilingual Europe.

Jason J. Nichols, OD, MPH, PHD, & L.S. (2020). *Contact Lenses 2019* (No. 35). Contact Lens Spectrum. Retrieved from https://www.clspectrum.com/issues/2020/january-2020/contact-lenses-2019

Jeyshankar, R., Babu, B. Ramesh, & Rajendran, P. (2011). Research output of CSIR-Central Electro Chemical Research Institute (CECRI): A study (No. 0975–2404). NISCAIR-CSIR. Retrieved from http://nopr.niscair.res.in/bitstream/123456789/13479/4/ALIS%2058%284%29%20301-306.pdf

Koehn, P., & Knowles, R. (2017). Six challenges for neural machine translation. Proceedings of the First Workshop on Neural Machine Translation, 28-39. http://www.aclweb.org/anthology/W17-3204

Koerner, E. F. K., & Asher, R. E. (2014). *Concise History of the Language Sciences. Elsevier Gezondheidszorg.* Edited by E.F.K.Koerner and R.E.Asher. Oxford: Pergamon Press, 1995. Pages 431-445]

Okpor, M. (2014). Machine Translation Approaches: Issues and Challenges. *International Journal of Computer Science Issues, Vol. 11, Issue 5. No. 2,* 159-165.

Poibeau, T. (2017). Criteria for a "Good" Translation. In *Machine Translation*. 16-17. MIT Press.

Poibeau, T. (2017). *Machine Translation.* London,Cambridge: The MITT Press.

Šteffan, P. *Návrh systémů s digitálními integrovanými obvody a mikroprocesory pro integrovanou výuku VUT a VŠB- TUO.* Návrh systémů s digitálními integrovanými obvody a mikroprocesory pro integrovanou výuku VUT a VŠB- TUO. První. Brno: Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií, 2014. ISBN: 978-80-214-5072- 1.

WU et al., Y. (2016). Google's Neural Machine Translation System: Bridging the Gap. between Human and Machine Translation. Technical Report. https://arxiv.org/pdf/1609.08144.pdf

Zehnalová, J. et al. (2015). *Kvalita a hodnocení překladu: Modely a aplikace.* Olomouc: Univerzita Palackého v Olomouci.

https://translate.google.cz/?hl=cs (24.5.2022)
https://translate.google.com/intl/en/about/languages/ (24.5.2022)
https://www.bing.com/translator?ref=MsftMT (24.5.2022)
https://www.microsoft.com/en-us/translator/ (24.5.2022)
https://cloud.google.com/translate/?hl=cs#section-1 (24.5.2022)
https://www.microsoft.com/en-us/translator/business/machine-translation/#nmt (24.5.2022)

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Abbreviation	Meaning
M	Multimédia
NSD	Návrh systémů s digitálními integrovanými obvody a mikroprocesory pro integrovanou výuku VUT a VŠB- TUO.
ESS	Elektronické součástky sbírka příkladů.
MST	Microsoft Translator
GT	Google Translate
L	Lexical errors
G	Grammatical errors
T	Translation errors

13 Appendix Corpus

Original text translated by the translators.

Original, M 1-11	Microsoft Translator	Google Translate	Errors
Vektorový obraz je složen ze základních geometrických tvarů, mezi něž patří body, křivky, přímky a mnohoúhelníky.	A vector image is composed of basic geometric shapes, which include points, curves, lines, and polygons.	A vector image is composed of basic geometric shapes, including points, curves, lines, and polygons.	GT-G
Vektorová grafika se uplatňuje v počítačové sazbě, při tvorbě počítačových animací, ilustrací apod.	Vector graphics are used in computer typesetting, in the creation of computer animations, illustrations, etc.	Vector graphics are used in computer typesetting, in the creation of computer animations, illustrations, etc.	
Obraz v bitmapové grafice, jinak zvané rastrové grafice, je složen z barevných bodů (pixelů).	An image in bitmap graphics, otherwise called raster graphics, is composed of color points (pixels).	An image in bitmap graphics, otherwise known as raster graphics, is composed of colored dots (pixels).	GT-L
Pořízení obrazu je velmi snadné, lze použít fotoaparát, videokamera, skener a jiná podobná zařízení.	Taking a picture is very easy, you can use a camera, camcorder, scanner and other similar devices.	Taking a picture is very easy, you can use a camera, camcorder, scanner and other similar devices.	
Digitální obraz je u bitmapové grafiky charakterizován jasem, barevnou hloubkou, rozlišením, kontrastem, dynamickým rozsahem a barevným modelem.	A digital image in bitmap graphics is characterized by brightness, color depth, resolution, contrast, dynamic range, and color model.	In bitmap graphics, the digital image is characterized by brightness, color depth, resolution, contrast, dynamic range, and color model.	
Jas je pro každý pixel definován jako jeho svítivost.	Brightness is defined for each pixel as its luminosity.	Brightness is defined for each pixel as its luminosity.	
Maximální hodnota jasu udává schopnost dané reprezentace obrazu rozlišit různé úrovně jasu = bitová hloubka obrazu.	The maximum brightness value indicates the ability of a given image representation to distinguish different levels of brightness = bit depth of the image.	The maximum brightness value indicates the ability of a given image representation to distinguish different brightness levels = image bit depth.	MST-G
Jednotka pro bitovou hloubku obrazu je bpp (Bits per Pixel).	The unit for bit depth of the image is bpp (Bits per Pixel).	The unit for image bit depth is bpp (Bits per Pixel).	MST-G
Megapixel značí jeden milion pixelů. Tato jednotka se používá u digitálních kamer a fotoaparátů.	Megapixel means one million pixels. This unit is used for digital cameras and cameras.	Megapixel means one million pixels. This unit is used with digital cameras and camcorders.	GT-L, GT-G
Kontrast digitálního obrazu je úzce spjat s fyziologií lidského zrakového systému. Kontrast digitálního obrazu kvantifikuje rozdíl nebo podíl jasu mezi nejsvětlejšími a nejtmavšími oblastmi.	The contrast of the digital image is closely related to the physiology of the human visual system. Digital image contrast quantifies the difference or proportion of brightness between the lightest and darkest areas.	The contrast of the digital image is closely linked to the physiology of the human visual system. Digital image contrast quantifies the difference or proportion of brightness between the lightest and darkest areas.	
Podíl hodnot nejvyššího a nejnižšího jasu se nazývá dynamický rozsah.	The ratio of the highest and lowest brightness values is called dynamic range.	The ratio of the highest and lowest brightness values is called the dynamic range.	

Table 1. Translations – M

Original, M 1-11	Microsoft Translator	Google Translate	Errors
Pro barevné obrazy existuje řada barevných modelů obsahujících komponenty pro popis barev.	For color images, there are a number of color models that contain color label components.	For color images, there are a number of color models that include color description components.	GT-L
Barevný model RGB využívá aditivní míchání barev, konkrétně červené $R(Red)$, zelené $G(Green)$ a modré $B(Blue)$.	The RGB color model uses additive color mixing, specifically red R(Red), green G(Green), and blue B(Blue).	The color model RGB uses additive color mixing, namely red Red (Red), green G ($Green$) and blue B ($Blue$).	GT-L
Aditivní míchání znamená, že sečtením jednotlivých barevných složek vznikne výsledná barva.	Additive mixing means that adding together the individual color components produces the resulting color.	Additive mixing means that adding the individual color components produces the final color.	
Barevný model RGB se používá při zobrazování barev na monitorech a různých displejích.	The RGB color model is used to display colors on monitors and various displays.	Color Model RGB is used to display colors on monitors and various displays.	
Variantou model RGB je model $ARGB$, kde je ke třem základním barvám přidán tzv. alfa kanál označující průhlednost snímku.	A variant of the RGB model is the ARGB model, where an alpha channel is added to the three basic colors to indicate the transparency of the image.	The model RGB variant is model $ARGB$, where the so-called alpha channel is added to the three basic colors, indicating the transparency of the image.	GT-G
Model lidského zrakového systému HVS (Human Visual System) poukazuje na skutečnost, že lidské oko je méně citlivé na barevné složky než na jasové složky obrazu.	The Human Visual System (HVS) model points to the fact that the human eye is less sensitive to color components than to the brightness components of an image.	The Human Visual System (HVS) model points to the fact that the human eye is less sensitive to color components than to the luminance components of an image.	
Z toho důvodu je možné barvy jistým způsobem potlačit, což se děje vzorkováním barvonosných složek.	For this reason, it is possible to suppress colors in a certain way, which is done by sampling color-bearing components.	For this reason, it is possible to suppress the colors in a certain way, which is done by sampling the color components.	GT-G, MST-L
Histogram u obrazových dat graficky znázorňuje rozložení a četnost jednotlivých barev, odstínu šedé apod.	The histogram of the image data graphically shows the distribution and frequency of individual colors, shade of gray, etc.	The histogram of the image data graphically shows the distribution and frequency of individual colors, shades of gray, etc.	
Vodorovná osa definuje jednotlivé úrovně, svislá osa potom četnost. Z histogramu lze lehce vyčíst expozici daného obrazu.	The horizontal axis defines the individual levels, the vertical axis then the frequency. From the histogram it is easy to read the exposure of the image.	The horizontal axis defines the individual levels, the vertical axis then the frequency. The exposure of the image can be easily read from the histogram.	
Prokládání bylo zavedeno z důvodu plynulosti pohybu ve videu při snímkových frekvencích 25 nebo 30 snímků za sekundu.	Interlacing was introduced because of the fluidity of motion in the video at frame rates of 25 or 30 frames per second.	Interlacing was introduced because of the smoothness of motion in the video at frame rates of 25 or 30 frames per second.	MST-L
Využilo se nedokonalosti lidského oka zachytit malé rychlé změny v obraze.	The imperfection of the human eye was used to capture small rapid changes in the image.	The imperfections of the human eye were used to capture small rapid changes in the image.	

Table 2. Translations – M

Original M 1-9	Microsoft Translator	Google Translate	Errors
Při prokládání je snímek rozdělen na dvě pole (půlsnímky), jeden půlsnímek obsahuje pouze sudé řádky snímku, druhý půlsnímek obsahuje pouze liché řádky pole.	When interlacing, the frame is divided into two fields (half-frames), one half-frame contains only even lines of the frame, the other half-frame contains only odd lines of the array.	When interleaving, the image is divided into two fields (fields), one field contains only even lines of the image, the other field contains only odd lines of the field.	GT-L, MST-L
Při těchto rychlostech lidské oko nedokáže postřehnout rozdíl, vnímá video jako plynulé.	At these speeds, the human eye cannot notice the difference, it perceives the video as smooth.	At these speeds, the human eye cannot notice the difference, it perceives the video as smooth.	
Video v počítači či záznamových zařízeních je uloženo po celých snímcích, rozdělení na sudý a lichý půlsnímek dochází až při jeho přehrávání.	Video on the computer or recording devices is stored whole frames, the division into even and odd half-frames occurs only when it is played.	The video on the computer or recording devices is stored in whole frames, the division into even and odd fields occurs only during its playback.	GT-G, MST-G
V případě, že vstupní obraz je širokoúhlý a počet sloupců je vyšší než je počet zobrazovaných sloupců, obraz se zmenší.	If the input image is widescreen and the number of columns is higher than the number of columns displayed, the image is reduced.	If the input image is widescreen and the number of columns is higher than the number of columns displayed, the image will be reduced.	GT-G
Vznikne v případě, kdy z původního formátu je vytvořen LetterBox na poměr stran 4:3 a ten je následně zobrazen na zobrazovači s poměrem stran 16:9.	It is created when a LetterBox is created from the original format for an aspect ratio of 4:3 and it is subsequently displayed on the display with an aspect ratio of 16:9.	It is created when a LetterBox with a 4: 3 aspect ratio is created from the original format and it is then displayed on a 16: 9 aspect ratio display.	
V případě zobrazení na obrazovku s poměrem stran 4:3 se obraz buď ořeže po stranách nebo se zmenší pomocí techniky PanScan.	In the case of display on a screen with a 4:3 aspect ratio, the image is either cropped to the sides or reduced using the PanScan technique.	When displayed on a 4: 3 screen, the image is either cropped to the sides or reduced using PanScan.	GT-L
Obsah scény digitálních obrazů a videí obsahuje často objekty s podobným zabarvením či jasem. Sousední pixely jsou často velmi podobné a jsou korelovány jak v prostoru, tak i v čase.	The scene content of digital images and videos often contains objects with similar timbre or brightness. Adjacent pixels are often very similar and are correlated in both space and time.	The scene content of digital images and videos often contains objects with similar color or brightness. Neighboring pixels are often very similar and are correlated in both space and time.	MST-L
Hodnota pixelu v obraze může být často predikována z určité skupiny pixelů v obraze (nejčastěji sousední pixely).	The pixel value in an image can often be predicted from a certain group of pixels in the image (most often adjacent pixels).	The value of a pixel in an image can often be predicted from a certain group of pixels in the image (most often neighboring pixels).	GT-L
Informační obsah jednotlivých pixelů je tedy malý. K odstranění redundance mezi pixely se nejčastěji používá kódování Run-Length, kdy výstupem kodéru je dvojice symbol+počet symbolů v řadě.	Thus, the information content of individual pixels is small. Run-Length encoding is most commonly used to eliminate redundancy between pixels, where the encoder output is a symbol+number of symbols in a row pair.	The information content of each pixel is therefore small. Run-Length encoding is most often used to eliminate redundancy between pixels, where the encoder outputs a pair of symbols + number of symbols in a row.	MST-L

Table 3. Translations – M

Original, M 1-11	Microsoft Translator	Google Translate	Errors
Dále je využíváno prediktivní kódování, které pracuje na principu, že následující pixel staví na předchozím pixelu.	In addition, predictive coding is used, which works on the principle that the next pixel builds on the previous pixel.	Furthermore, predictive coding is used, which works on the principle that the next pixel builds on the previous pixel.	GT-L, MST-L
Výstupem prediktivního kódování je potom rozdíl mezi aktuální a predikovanou hodnotou.	The output of predictive coding is then the difference between the current and the predicted value.	The output of the predictive coding is then the difference between the current and the predicted value.	MST-G
Pro redukci redundance v čase se používají metody odhadu a kompenzace pohybu.	To reduce redundancy over time, methods of estimation and compensation of movement are used.	Estimation and motion compensation methods are used to reduce redundancy over time.	
Podrobnější popis zmíněných principů a metod najdete v dalších kapitolách těchto skript.	A more detailed description of these principles and methods can be found in the next chapters of these scripts.	You will find a more detailed description of the mentioned principles and methods in the next chapters of these scripts.	
Odstraněním této redundance se zabývají techniky, které standardní kód, kdy každý symbol je kódován kódovým slovem fixní délky, nahradí kódem proměnné délky.	To eliminate this redundancy, techniques are involved in replacing standard code, where each symbol is encoded with a fixed-length code word, with a variable length code.	This redundancy is addressed by techniques that replace the standard code, where each symbol is encoded with a fixed-length codeword, with a variable-length code.	GT-L
Délka kódů představujících jednotlivé symboly závisí na pravděpodobnosti výskytu každého symbolu.	The length of the codes representing each symbol depends on the probability of each symbol occurring.	The length of the codes representing each symbol depends on the probability of each symbol occurring.	
Platí pravidlo, že s rostoucí pravděpodobností daného symbolu klesá počet bitů potřebných na vyjádření symbolu.	As a rule, as the probability of a given symbol increases, the number of bits needed to express the symbol decreases.	The rule is that as the probability of a given symbol increases, the number of bits needed to express the symbol decreases.	
Typickými zástupci metod odstraňujících kódovou redundanci jsou Huffmanovy kódy, slovníkové kódy a aritmetické kódy.	Typical representatives of methods that eliminate code redundancy are Huffman codes, dictionary codes, and arithmetic codes.	Typical representatives of code redundancy removal methods are Huffman codes, dictionary codes, and arithmetic codes.	
Jasové maskování se zaměřuje na vnímání jasu lidským zrakovým systémem.	Brightness masking focuses on the perception of brightness by the human visual system.	Brightness masking focuses on the perception of brightness by the human visual system.	
Weberův zákon platí pro velký rozsah hodnot *I*.	Weber's law applies to a large range of I values.	Weber's law applies to a wide range of values *I* .	
Ze vztahu je patrné, že pro světlé pozadí je zapotřebí větší rozdíl intenzit jasu pro rozeznání dvou objektů, pro tmavé pozadí je zapotřebí menší rozdíl intenzit pro rozeznání dvou objektů.	It is clear from the relationship that for a light background, a greater difference in brightness intensities is needed to distinguish two objects, for a dark background, a smaller difference in intensity is needed to recognize two objects.	It is clear from the relationship that for a light background a larger difference in brightness intensities is needed to recognize two objects, for a dark background a smaller difference in intensities is needed to recognize two objects.	MST-L, GT-L

Table 4. Translations – M

Original, M 1-12	Microsoft Translator	Google Translate	Errors
Frekvenční maskování není závislé na obsahu scény.	Frequency masking does not depend on the content of the scene.	Frequency masking does not depend on the content of the scene.	
Lidský zrakový systém je více náchylný na nízkofrekvenční složky obrazu než na vysokofrekvenční.	The human visual system is more susceptible to low-frequency components of the image than to high-frequency ones.	The human visual system is more susceptible to the low-frequency components of the image than to the high-frequency.	MST-G, MST-G
Vysokofrekvenční složky se tedy mohou v určité míře potlačovat bez viditelné degradace obrazu.	Thus, high-frequency components can be suppressed to some extent without visible image degradation.	Thus, the high frequency components can be suppressed to some extent without visible image degradation.	
Dočasné maskování je možné využít u video-sekvencí, kdy při změně scény ve videu lidské oko určitou dobu plně nevnímá detaily.	Temporary camouflage can be used for video sequences, when changing a scene in a video, the human eye does not fully perceive the details for a certain period of time.	Temporary masking can be used for video sequences, when the human eye does not fully perceive details for a while when changing the scene in the video.	GT-L
Lidský zrakový systém je více citlivý na jas než na barvu.	The human visual system is more sensitive to brightness than to color.	The human visual system is more sensitive to brightness than to color.	
Měření a hodnocení vizuální kvality digitálních obrazů a videí je velmi složité, neboť kvalitu ovlivňuje mnoho na sobě nezávislých faktorů.	Measuring and evaluating the visual quality of digital images and videos is very complex, as quality is influenced by many independent factors.	Measuring and evaluating the visual quality of digital images and videos is very complex, as quality is affected by many independent factors.	MST-L
Kvalitu obrazu lze hodnotit buď subjektivně nebo objektivně.	Image quality can be evaluated either subjectively or objectively.	Image quality can be evaluated either subjectively or objectively.	
Subjektivní měření kvality je velmi závislé na pozorovateli a nelze tedy určit či definovat přesné kvalitativní měřítko.	Subjective quality measurement is highly dependent on the observer and therefore it is not possible to determine or define an accurate quality scale.	Subjective quality measurement is highly dependent on the observer and it is therefore not possible to determine or define an exact quality measure.	GT-L
U objektivního měření existují daná kritéria i měřítko, avšak systémy, měřící obrazová data objektivně, nemohou kompletně reprodukovat subjektivní vnímání.	In objective measurement, there are given criteria and a scale, but systems measuring image data objectively cannot completely reproduce subjective perception.	For objective measurement, there are criteria and scales, but systems that measure image data objectively cannot completely reproduce subjective perception.	
Hodnotitel tedy nikdy neví, zda se jedná o originál či upravenou kopii.	Therefore, the evaluator never knows whether it is an original or a modified copy.	Therefore, the evaluator never knows whether it is the original or a modified copy.	
Na konci testování jsou výsledky konvertovány do normalizovaného rozsahu.	At the end of testing, the results are converted to a normalized range.	At the end of testing, the results are converted to the normalized range.	GT-G
Expert v oblasti kompresí videosekvencí/obrazu může hodnotit neobjektivně.	An expert in the field of video/image compression can evaluate biased.	An expert in video / image compression can evaluate biasedly.	MST-L

Table 5. Translations – M

Original, M 1-10	Microsoft Translator	Google Translate	Errors
Objektivní měření kvality lze na rozdíl od subjektivního měření kvality plně automatizovat algoritmizací.	Objective quality measurement, unlike subjective quality measurement, can be fully automated by algorithms.	Unlike subjective quality measurement, objective quality measurement can be fully automated by algorithmization.	GT-L
Tím je měření podstatně levnější. Vývojáři kompresních technik obrazu a videa často používají objektivní techniky díky rychlosti a jednoduchosti implementace a možnosti reálného srovnání výsledků s konkurencí.	This makes the measurement significantly cheaper. Developers of image and video compression techniques often use objective techniques due to the speed and simplicity of implementation and the possibility of a real comparison of results with competitors.	This makes the measurement significantly cheaper. Developers of image and video compression techniques often use objective techniques due to the speed and simplicity of implementation and the ability to realistically compare results with competitors.	GT-L
Tato metoda má však své limity.	However, this method has its limits.	However, this method has its limits.	
V současné době existují i mnohem propracovanější metody pro měření kvality, které berou v úvahu reálné lidské vnímání.	At present, there are also much more sophisticated methods for measuring quality that take into account real human perception.	At present, there are also much more sophisticated methods for measuring quality that take into account real human perception.	
Vyjádřená podobnost by tedy měla odpovídat tomu, jak rozdíl vnímá lidské oko.	Thus, the expressed similarity should correspond to how the difference is perceived by the human eye.	The similarity expressed should therefore correspond to how the difference is perceived by the human eye.	
Metoda pracuje s předpokladem, že jas na povrchu objektu je produktem osvětlení a odrazu, ale struktura objektů je na jasu nezávislá.	The method works with the assumption that the brightness on the surface of the object is a product of illumination and reflection, but the structure of the objects is independent of brightness.	The method works on the assumption that the brightness on the surface of the object is a product of illumination and reflection, but the structure of the objects is independent of the brightness.	
Snahou tvůrců této metody je odstranit vlivy osvětlení na výsledky měření podobnosti.	The aim of the creators of this method is to eliminate the effects of lighting on the results of similarity measurements.	The creators of this method strive to eliminate the effects of lighting on the results of similarity measurements.	
Autoři tento postup ale nedoporučují, navrhují oba obrazové signály rozdělit na pole o velikosti 8x8 px a SSIM index spočítat pro každé dvě odpovídající si pole zvlášť.	However, the authors do not recommend this procedure, they propose to divide both image signals into an array of 8x8 px and calculate the SSIM index for each two corresponding fields separately.	However, the authors do not recommend this procedure, they suggest splitting both video signals into an 8x8 px field and calculating the SSIM index for each of the two corresponding fields separately.	GT-L
Při kódování obrazových dat se často místo hodnot pixelů kódují rozdíly mezi hodnotami pixelů a jejich predikcí.	When encoding image data, differences between pixel values and their prediction are often encoded instead of pixel values.	When encoding image data, differences between pixel values and their predictions are often encoded instead of pixel values.	
Prediktivnímu kódování u obrazových dat velmi napomáhá vzájemná prostorová/časová korelace mezi pixely.	Predictive encoding of image data is greatly helped by the spatial/temporal correlation between pixels.	Predictive coding for image data is greatly aided by spatial / temporal correlation between pixels.	GT-G

Table 6. Translations - M

Original, M 1-10	Microsoft Translator	Google Translate	Errors
Při předpokladu, že hodnota pixelu originálního obrazu je vyjádřena osmi bity, má obraz 256 úrovní.	Assuming that the pixel value of the original image is expressed by eight bits, the image has 256 levels.	Assuming that the pixel value of the original image is expressed as eight bits, the image has 256 levels.	
Blokové schéma základního kodéru a dekodéru DPCM	Block diagram of the basic DPCM encoder and decoder	Block diagram of basic encoder and DPCM decoder	GT-L
V příkladech popsaných v předchozí kapitole se používal sousední rekonstruovaný pixel pro predikci právě kódovaného pixelu.	In the examples described in the previous chapter, the adjacent reconstructed pixel was used to predict the pixel being encoded.	In the examples described in the previous chapter, a neighboring reconstructed pixel was used to predict the currently encoded pixel.	
Obecně v systémech DPCM je hodnota pixelu nejprve predikována, následně je vypočítán rozdíl mezi skutečnou a predikovanou hodnotou signálu a tento rozdíl je nakonec kvantován.	In general, in DPCM systems, the pixel value is first predicted, then the difference between the actual and predicted value of the signal is calculated, and this difference is finally quantized.	In general, in DPCM systems, the pixel value is first predicted, then the difference between the actual and predicted signal value is calculated, and this difference is finally quantized.	
Využívá se například v kompresním standardu pro obraz JPEG, v kompresních kodérech pro video MPEG. H.26x apod.	It is used, for example, in the compression standard for JPEG images, in compression encoders for MPEG video. H.26x etc.	It is used, for example, in the compression standard for JPEG images, in compression encoders for MPEG video. H.26x apod.	GT-T
Vzorky z prostorové oblasti jsou transformovány do jiné reprezentace (transformační domény).	Samples from the spatial region are transformed into another representation (transformation domain).	Spatial samples are transformed into another representation (transformation domain).	
Díky tomu je velmi těžké data v prostorové oblasti redukovat bez ztráty kvality výsledného obrazu.	This makes it very difficult to reduce the data in the spatial area without losing the quality of the resulting image.	This makes it very difficult to reduce spatial data without losing the quality of the resulting image.	
Transformační kódování koncentruje energii do malého počtu vzorků, které jsou však velmi důležité – dekoreluje vstupní data.	Transformation coding concentrates energy in a small number of samples, which are very important – it decorates the input data.	Transform coding concentrates energy into a small number of samples, which are very important - it decorates the input data.	
Transformace, které jsou využívány při kompresi obrazových dat, jsou vždy lineární.	The transformations that are used in image data compression are always linear.	The transformations that are used to compress image data are always linear.	
Pro digitální obrazy a video se využívá transformace dvourozměrná (2D).	For digital images and video, two-dimensional (2D) transformation is used.	Two-dimensional (2D) transformation is used for digital images and video.	

Table 7. Translations - M

Original, M 1-2, NSD 3-10	Microsoft Translator	Google Translate	Errors
Diskrétní kosinová transformace se používá v obrazových a video kodecích díky tomu, že dokáže efektivně transformovat obraz do podoby, která je vhodná ke kompresi a zároveň proto, že je vhodná jak k softwarové, tak i hardwarové implementaci.	Discrete cosine transformation is used in image and video codecs due to the fact that it can efficiently transform an image into a form that is suitable for compression and at the same time because it is suitable for both software and hardware implementation.	Discrete cosine transform is used in image and video codecs because it can efficiently transform an image into a form that is suitable for compression and at the same time because it is suitable for both software and hardware implementations.	GT-L
Tento interval se nazývá NOSIČ.	This interval is called CARRIER.	This interval is called the CARRIER.	MST-G
Číslicové systémy se dnes realizují několika základními způsoby.	Digital systems today are implemented in several basic ways.	Digital systems are implemented today in several basic ways.	
Komponenty číslicových systémů se vyrábějí prakticky výhradně ve formě integrovaných obvodů.	Components of digital systems are produced almost exclusively in the form of integrated circuits.	Digital system components are manufactured almost exclusively in the form of integrated circuits.	
Nabízená řešení jsou proto většinou univerzální, použitelná v širokém spektru zařízení a systémů.	The solutions offered are therefore mostly universal, usable in a wide range of devices and systems.	The offered solutions are therefore mostly universal, usable in a wide range of devices and systems.	
Pro složité systémy byly vytlačeny programovatelnými logickými obvody a mikrokontroléry, ale i tyto prvky nejsou schopny pracovat bez základních logických obvodů.	For complex systems, they have been displaced by programmable logic circuits and microcontrollers, but even these elements are not able to work without basic logic circuits.	For complex systems, they have been pushed out by programmable logic circuits and microcontrollers, but even these elements are not able to work without basic logic circuits.	MST-L
Bylo by možné očekávat, že pro vyjádření logických funkcí většího počtu proměnných bude nutné zavádět další složitější základní logické funkce.	It would be expected that in order to express the logical functions of a larger number of variables, it would be necessary to introduce other more complex basic logical functions.	It would be expected that it would be necessary to introduce other more complex basic logic functions to express the logical functions of a larger number of variables.	
Lze však ukázat, že jakoukoliv kombinační logickou funkci libovolného množství proměnných je možné vyjádřit pomocí několika elementárních logických funkcí.	However, it can be shown that any combinatorial logical function of any number of variables can be expressed using several elementary logical functions.	However, it can be shown that any combinational logic function of any number of variables can be expressed using several elementary logic functions.	
Pravdivostní tabulka obsahuje vstupní a výstupní logické proměnné.	The truth table contains input and output logical variables.	The truth table contains input and output logical variables.	
Při tomto způsobu zápisu vyjadřují uvedená čísla stav jednotlivých vstupních proměnných a označují se jako stavový index.	In this way of writing, the given numbers express the state of each input variable and are referred to as the status index.	In this notation, the numbers indicate the status of the individual input variables and are referred to as the status index.	MST-L

Table 8. Translations – M, NSD

Original, NSD 1-9	Microsoft Translator	Google Translate	Errors
Pravdivostní tabulka představuje nejjednodušší způsob zápisu kombinačních logických funkcí.	The truth table is the easiest way to write combination logical functions.	The truth table is the simplest way to write combinational logic functions.	GT-L
Při větším počtu vstupních proměnných však může být tento způsob zápisu nepohodlný pro značný počet řádků tabulky.	However, with a larger number of input variables, this method of writing can be inconvenient for a significant number of table rows.	However, with a large number of input variables, this method of writing can be inconvenient for a large number of table rows.	MST-L
První z těchto způsobů zápisu je tvořen součtem součinových termů.	The first of these ways of writing is formed by the sum of the product terms.	The first of these notation methods is the sum of the product terms.	MST-L, GT-L
Mezi zápisem kombinační logické funkce pomocí pravdivostní tabulky a zápisem této funkce v úplném součtovém nebo součinovém tvaru je úzká souvislost.	There is a close connection between writing a combinatorial logical function using a truth table and writing that function in full sum or product form.	There is a close connection between writing a combinational logic function using a truth table and writing this function in full sum or product form.	
Při nákresu mapy na rovinný list je možno tuto podmínku dodržet, není-li počet vstupních proměnných větší než čtyři.	When drawing the map on a planar sheet, this condition can be met if the number of input variables is not more than four.	When drawing the map on a planar sheet, this condition can be met if the number of input variables is not greater than four.	
Ke zjednodušování se používají různé metody, z nichž zde uvedeme metodu algebraických úprav a metodu využívající Karnaughových map.	Various methods are used for simplification, of which we will present here the method of algebraic adjustment and the method using Karnaugh maps.	Various methods are used for simplification, of which we present here the method of algebraic adjustments and the method using Karnaugh maps.	
I na složitější algoritmy, používané v počítačových programech, můžeme však často bez velké újmy na přesnosti pohlížet jako na algoritmy, které aspoň z hlediska uživatele fungují obdobně jako metody založené na použití Karnaughových map	However, even more complex algorithms used in computer programs can often be viewed without much harm to accuracy as algorithms that, at least from the user's point of view, work similarly to methods based on the use of Karnaugh maps.	However, even more complex algorithms used in computer programs can often be seen without much loss of accuracy as algorithms that, at least from the user's point of view, work similarly to methods based on the use of Karnaugh maps.	GT-L
Při zobrazení v mapě jsou takové dvojice mintermů zřejmé na první pohled a jejich sloučení znamená jejich nahrazení termem s počtem proměnných o jednu menší.	When displayed on a map, such pairs of minterms are obvious at first glance, and merging them means replacing them with a term with a number of variables one smaller.	When displayed on the map, such pairs of minterms are obvious at first glance, and merging them means replacing them with a term with one smaller number of variables.	GT-L
Podobně dvě takové dvojice spolu sousedících buněk představují čtveřici, vyjadřující term, u něhož je vyloučena proměnná, která v původních termech měla nestejný znak inverze, tj. v jedné vystupovala přímo a v druhé v inverzi.	Similarly, two such pairs of adjacent cells represent a foursome, expressing a term in which a variable is excluded that in the original terms had an unequal sign of inversion, i.e. in one it acted directly and in the other in inversion.	Similarly, two such pairs of contiguous cells represent a quadruple, expressing a term for which a variable is excluded, which in the original terms had an unequal sign of inversion, i.e. in one it acted directly and in the other in inversion.	GT-T, GT-L

Table 9. Translations – NSD

Original, NSD 1-8	Microsoft Translator	Google Translate	Errors
Při slučování termů v mapě vyznačujeme slučované buňky pomocí smyček.	When merging the terms in the map, we mark the merged cells using loops.	When merging terms in the map, we mark the merged cells using loops.	
Realizací kombinační logické funkce rozumíme sestavení schématu zapojení obvodu, který ze vstupních proměnných vytvoří výstupní proměnné v souhlasu se zadanou logickou funkcí.	By implementing a combination logic function, we mean the compilation of a circuit wiring diagram that creates output variables from input variables in accordance with the specified logical function.	By the implementation of a combinational logic function we mean the construction of a circuit diagram which, from the input variables, creates the output variables in accordance with the given logic function.	GT-L
Ve zvláštních případech lze k realizaci kombinační logické funkce využít i jiných prostředků (např. tranzistorů a diod), což může být vhodné například tam, kde nemáme k dispozici vhodný napájecí zdroj pro digitální obvody a jeho vytvoření by bylo složitější než realizace kombinační logické funkce uvedeným způsobem.	In special cases, other means (e.g. transistors and diodes) can also be used to implement the combination logic function, which may be appropriate, for example, where we do not have a suitable power supply for digital circuits and its creation would be more complicated than the implementation of the combinatorial logic function in this way.	In special cases, other means (eg transistors and diodes) can be used to implement the combinational logic function, which may be suitable, for example, where we do not have a suitable power supply for digital circuits and its creation would be more complicated than the implementation of the combinational logic function. way.	GT-G, GT-T
Výhodou je, že signál ze součinové části postupuje do součtové části uvnitř pouzdra, takže je zde menší zpoždění, než kdyby musel procházet přes vývody.	The advantage is that the signal from the product part progresses to the sum part inside the housing, so there is less delay than if it had to pass through the pins.	The advantage is that the signal from the product part proceeds to the sum part inside the housing, so there is less delay than if it had to pass through the terminals.	GT-L
Datové vstupy jsou očíslovány a jejich počet se shoduje s počtem možných adresových kombinací.	The data inputs are numbered and their number coincides with the number of possible address combinations.	The data inputs are numbered and their number matches the number of possible address combinations.	
Signál z datového vstupu s číslem odpovídajícím dekadické hodnotě adresy je multiplexorem převeden na výstup.	The signal from the data input with a number corresponding to the decimal value of the address is converted to the output by the multiplexer.	The signal from the data input with the number corresponding to the decimal value of the address is converted to output by the multiplexer.	
Tyto obvody se vyrábějí ve velkých sériích, jsou proto levné a dokonale propracované z hlediska funkčních vlastností.	These circuits are produced in large series, so they are inexpensive and perfectly sophisticated in terms of functional properties.	These circuits are manufactured in large series, so they are cheap and sophisticated in terms of functional properties.	MST-L
Jsou proto vhodné tam, kde potřebujeme realizovat složité funkce mnoha proměnných, zejména odpovídá-li počet realizovaných funkcí počtu výstupů vyráběných pamětí.	They are therefore suitable where we need to realize complex functions of many variables, especially if the number of realized functions corresponds to the number of outputs produced by the memory.	They are therefore suitable where we need to implement complex functions of many variables, especially if the number of implemented functions corresponds to the number of outputs produced by memory.	

Table 10. Translations – NSD

Original, NSD 1-10	Microsoft Translator	Google Translate	Errors
Realizace pomocí multiplexerů je vhodná pro jednu funkci (nebo malý počet funkcí) s nevelkým počtem vstupních proměnných (čtyři až pět, kde lze vystačit s jedním pouzdrem multiplexeru).	Implementation using multiplexers is suitable for one function (or a small number of functions) with a small number of input variables (four to five, where it is possible to make do with one multiplexer housing).	Implementation using multiplexers is suitable for one function (or a small number of functions) with a small number of input variables (four to five, where one multiplexer housing can suffice).	
Paměťové buňky se proto umísťují do matice, v níž se každá buňka adresuje koincidenčně pomoci vybraného sloupce a řádku.	Therefore, memory cells are placed in a matrix in which each cell is addressed coincidentally using the selected column and row.	Memory cells are therefore placed in a matrix in which each cell is addressed coincidentally with the selected column and row.	
Tato paměť se používá obdobně jako paměť ROM.	This memory is used similarly to ROM memory.	This memory is used similarly to ROM.	GT-L
Pokud je na elektrodě D nulové napětí, kanálem neteče proud a nedojde k přeskoku elektronů a naprogramování paměťové buňky.	If there is zero voltage on the electrode D, there is no current flowing through the channel and electrons will not jump and the memory cell will be programmed.	If there is zero voltage on the electrode D, no current flows through the channel and no electron jump and no programming of the memory cell occurs.	MST-L
Protože k tunelování dochází při velké intenzitě elektrického pole mezi těmito elektrodami, není nutný žádný proud kanálem.	Since tunneling occurs at a high intensity of the electric field between these electrodes, no current through the channel is required.	Because tunneling occurs at high electric field strengths between these electrodes, no current through the channel is required.	
Proces tunelování je relativně pomalý a pomalé je tedy i programování paměťových buněk.	The tunneling process is relatively slow and the programming of memory cells is also slow.	The tunneling process is relatively slow, so memory cell programming is slow.	GT-L
Programování probíhá injekcí horkých elektronů z kanálu při přivedeném zvýšeném napětí na řídicím hradle.	Programming is done by injecting hot electrons from the channel with an increased voltage at the control gate.	The programming is performed by injecting hot electrons from the channel at an increased voltage applied to the control gate.	
Většina paměťových čipů proto v sobě obsahuje nábojovou pumpu (charge pump), která zajistí vygenerování potřebného programovacího napětí.	Most memory chips therefore contain a charge pump, which ensures the generation of the necessary programming voltage.	Therefore, most memory chips contain a charge pump, which ensures the generation of the necessary programming voltage.	
Výrobci se proto snaží o vyvinutí nových paměťových buněk, založených na jiném principu uložení informace.	Therefore, manufacturers are trying to develop new memory cells, based on a different principle of storing information.	Manufacturers are therefore trying to develop new memory cells based on a different principle of storing information.	GT-G
Magnetické pole proměnné magnetické vrstvy je tedy řízené vybuzeným magnetickým polem při zápisu logického stavu bitu.	The magnetic field of the variable magnetic layer is thus controlled by the excited magnetic field when writing the logical state of the bit.	The magnetic field of the variable magnetic layer is thus controlled by the excited magnetic field when writing the logic state of the bit.	

Table 11. Translations – NSD

Original, NSD 1-12	Microsoft Translator	Google Translate	Errors
Zatímco u klasických buněk pamětí RAM dochází s časem a se zjišťováním stavu bitu k úbytku náboje a je nutné po čase buňky tzv. regenerovat, u pamětí MRAM není nic takového nutné.	While in classic RAM cells there is a loss of charge with time and with the determination of the bit state and it is necessary to regenerate the cells over time, with MRAM nothing like this is necessary.	While in conventional RAM cells the charge decreases with time and bit status and it is necessary to regenerate the cells over time, in MRAMs nothing like this is necessary.	GT-L, GT-L
Měřený proud je porovnáván s referenční hodnotou proudu protékajícího strukturou při stavu L.	The measured current is compared with the reference value of the current flowing through the structure at the L state.	The measured current is compared with the reference value of the current flowing through the structure at state L.	
Paměti RWM (Read Write Memory) jsou paměti určené pro opakované čtení i zápis.	Read Write Memory (RWM) is read/write memory.	RWM (Read Write Memory) is a memory for read and write.	MST-L, GT-L
Základem těchto pamětí bývá bistabilní klopný obvod.	The basis of these memories is a bistable flip-flop circuit.	The basis of these memories is usually a bistable flip-flop.	GT-L
V reálných podmínkách musíme vycházet z velmi malé kapacity paměťového kapacitoru.	In real conditions, we have to start from a very small capacity of the memory capacitor.	In real conditions we have to start from a very small capacity of the memory capacitor.	
Ty se následně podle čtené informace překlopí do stabilního stavu, a tím obnoví uloženou informaci.	These are then switched to a stable state according to the read information, thereby restoring the stored information.	These are then switched to a stable state according to the read information, thus restoring the stored information.	
K vlastnímu návrhu je možné přistoupit až po vykonání dalších kroků, které se souhrnně nazývají fyzický návrh.	It is possible to proceed to the actual design only after performing the next steps, which are collectively called a physical design.	It is possible to proceed to the design itself only after performing other steps, which are collectively called physical design.	GT-L
Při fyzickém návrhu postupujeme většinou s ohledem na nejméně příznivé podmínky.	When making a physical design, we usually proceed with regard to the least favorable conditions.	In the physical design, we usually proceed with regard to the least favorable conditions.	
Cílem fyzického návrhu je bezpečná funkce navržených zařízení a jednoduchost návrhu.	The goal of physical design is the safe function of the designed devices and the simplicity of the design.	The goal of physical design is the safe operation of the designed devices and the simplicity of the design.	
Bipolární technologie je nejstarší, do hloubky propracovaná a dříve hodně používaná skupina logických obvodů.	Bipolar technology is the oldest, deeply developed and previously widely used group of logic circuits.	Bipolar technology is the oldest, most in-depth and previously widely used group of logic circuits.	GT-L
Základem každého typu digitálních integrovaných obvodů je možnost realizace logických funkcí.	The basis of each type of digital integrated circuits is the possibility of realizing logical functions.	The basis of every type of digital integrated circuits is the possibility of implementing logic functions.	

Table 12. Translations – NSD

Original, NSD 1-4, ESS 5-9	Microsoft Translator	Google Translate	Errors
Další varianty obvodů byly vyvinuty s cílem buď zmenšit příkon nebo zmenšit zpoždění signálu nebo v optimálním případě zmenšit i příkon i zpoždění.	Other circuit variants have been developed with the aim of either reducing power consumption or signal delay or, in the optimal case, reducing both power consumption and delay.	Other circuit variants have been developed to either reduce power consumption or signal delay, or optimally reduce both power consumption and delay.	
Většina bipolárních obvodů TTL je v dnešní době nahrazena obvody v technologii unipolární, pro přehled zde ale uvedeme ukázky v rozdílech parametrů jednotlivých obvodových řad.	Most of the bipolar TTL circuits are nowadays replaced by circuits in unipolar technology, but for an overview we will give examples in the differences in the parameters of individual circuit series.	Most TTL bipolar circuits are nowadays replaced by unipolar circuits, but for an overview we will show examples of differences in the parameters of individual circuit series.	
Je uvažována diodová varianta vstupu hradla řady LS.	A diode variant of the LS series gate inlet is considered.	A diode variant of the LS series gate input is considered.	
Uváděné hodnoty jsou pouze orientační.	The stated values are only indicative.	The values given are for guidance only.	GT-L
Při přibližování dvou atomů dochází k projevům přitažlivých (vazebních, atraktivních) a odpudivých (repulsivních) sil.	When two atoms approach, there are manifestations of attractive (binding, attractive) and repulsive (repulsive) forces.	When two atoms approach, there are manifestations of attractive (binding, attractive) and repulsive (repulsive) forces.	
V případě velké vzdálenosti mezi jednotlivými atomy je energetické spektrum čárové, protože jednotlivé atomy spolu neinteragují.	In the case of a large distance between individual atoms, the energy spectrum is linear, since the individual atoms do not interact with each other.	In the case of a large distance between individual atoms, the energy spectrum is linear because the individual atoms do not interact with each other.	
Pokud bude energie některého elektronu větší, než je tato energie, může dojít k jeho uvolnění z krystalu.	If the energy of an electron is greater than this energy, it can be released from the crystal.	If the energy of an electron is greater than this energy, it may be released from the crystal.	
Poslední tři pásy – vodivostní, zakázaný a valenční – svojí polohou a energetickou šířkou určují základní vlastnosti pevných látek z hlediska vedení elektrického proudu (přenosu náboje).	The last three bands – conductivity, forbidden and valence – by their position and energy width determine the basic properties of solids in terms of conduction of electric current (charge transfer).	The last three bands - conductivity, forbidden and valence - with their position and energy width determine the basic properties of solids in terms of current conduction (charge transfer).	GT-L
Objev dovolených a zakázaných pásů energie v krystalických látkách vedl k jednoduchému a názornému výkladu elektrické vodivosti.	The discovery of permitted and forbidden bands of energy in crystalline substances led to a simple and illustrative interpretation of electrical conductivity.	The discovery of allowed and forbidden energy bands in crystalline substances has led to a simple and illustrative interpretation of electrical conductivity.	

Table 13. Translations – NSD, ESS

Original, ESS 1-5	Microsoft Translator	Google Translate	Errors
Výpočty při teplotě absolutní nuly jsou jenom teoretickou abstrakcí, která nám umožňuje jednodušší postupy a snazší pochopení problému než při uvažování reálných teplot.	Calculations at absolute zero are only a theoretical abstraction that allows us simpler procedures and easier to understand the problem than when considering real temperatures.	Calculations at absolute zero temperature are just a theoretical abstraction, which allows us to simplify procedures and easier to understand the problem than when considering real temperatures.	
Za teploty 0 K je vodivostní pás prázdný, tj. v polovodiči nejsou žádné volné elektrony, které by mohly vést proud.	At a temperature of 0 K, the conductivity band is empty, i.e. there are no free electrons in the semiconductor that could conduct current.	At 0 K, the conduction band is empty, ie there are no free electrons in the semiconductor that could conduct current.	GT-L
Kladný iont se může zneutralizovat přijetím elektronu, který k němu přejde ze sousedního atomu.	A positive ion can be neutralized by receiving an electron that passes to it from a neighboring atom.	A positive ion can be neutralized by accepting an electron that passes to it from a neighboring atom.	
Takovýto mechanismus pohybu elektronu označujeme jako děrovou vodivost, abychom jej rozlišili od elektronů uvolněných z vazby mezi atomy.	We refer to such a mechanism of electron motion as hole conductivity to distinguish it from electrons released from the bond between atoms.	We refer to such an electron motion mechanism as hole conductivity to distinguish it from electrons released from a bond between atoms.	GT-G
Intrinzické polovodiče se proto běžně nepoužívají.	Therefore, intrinsic semiconductors are not commonly used.	Intrinsic semiconductors are therefore not commonly used.	

Table 14. Translations - ESS

	Original	Microsoft Translator	Google Translate
Words	2212	2766	2699
Characters with spaces	15500	17016	16649

Table 15. Words and Characters of original and translated texts

	M	NSD	ESS
Original characters	8268	6001	1231
Characters after Microsoft Translator	9155	6532	1329
Characters after Google Translate	9001	6337	1311

Table 16. Size in characters of each sample text in original and translated forms

Microsoft Translator	M	NSD	ESS
Lexical errors	9	7	0
Grammatical errors	7	0	0
Translation Errors	0	0	0

Table 17. Errors made by the Microsoft Translator

Google Translate	M	NSD	ESS
Lexical errors	17	16	2
Grammatical errors	8	2	1
Translation Errors	1	2	0

Table 18. Errors made by the Google Translate

	Lexical errors	Grammatical errors	Translation Errors
Microsoft Translator	16	7	0
Google Translate	35	11	3

Table 19. Total errors made by each translator