



Modern Machine Translation Technologies: Linguistic Analysis And Hybrid Models

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ABSTRACT

This article comparatively examines the functional capabilities and methodological limitations of existing machine translation approaches and substantiates the need to integrate the effective features of individual approaches. In addition, the use of a hybrid machine translation approach is identified as a promising direction for reducing semantic and contextual ambiguities, ensuring translation equivalence, and improving the adequacy and quality of the translation output.

KEYWORDS: Natural language, automatic translation, linguistic analysis, semantic ambiguity, contextual analysis, translation equivalence, hybrid approach, translation quality, extralinguistic factors.

INTRODUCTION

Machine translation has long been studied as one of the actively developing areas of scientific research in the field of artificial intelligence. Machine translation (MT) is a complex linguistic and technological process, since natural languages have a multilayered and complex structure, many lexical units are polysemantic, and they may be expressed through different translation equivalents depending on the context. In addition, sentences and syntactic constructions may have several semantic interpretations, while semantic, syntactic, and pragmatic relations between linguistic units may not always be clearly delimited. Therefore, in some cases, the translation process requires taking into account not only linguistic knowledge but also general knowledge about reality, contextual information, and extralinguistic factors.

The extremely large number of interrelations in natural language and their complex structural-semantic nature limit the possibility of simultaneously and fully modelling all linguistic and extralinguistic factors in a machine translation system. Under these conditions, a machine translation system is required to select a particular translation solution on the basis of incomplete linguistic and contextual information and to generate the corresponding translation variant in the target language. This makes the improvement of decision-making mechanisms, context identification, and the selection of optimal translation equivalents relevant scientific problems in the machine translation process.

Various theoretical, linguistic, statistical, and technological approaches can be used to solve this problem. The study analyses existing approaches to machine translation, their methodological characteristics, functional capabilities, and the problems that arise in the process of their practical application. The research results show that there is no single approach to machine translation that is absolutely perfect and equally effective in all cases. At the same time, the

linguistic and technological limitations observed in some approaches are manifested to a relatively minimal extent.

From this perspective, it is considered appropriate to develop a hybrid machine translation model based on the integration of the most effective methods, algorithmic capabilities, and functional advantages of different machine translation approaches. Such an integrative approach makes it possible to compensate for the shortcomings inherent in individual methods, reduce semantic and contextual ambiguities arising in the translation process, ensure translation equivalence, and improve the linguistic adequacy and quality indicators of the final translation output.

Literature Review

As a result of integrating the advantages of statistical and rule-based translation methodologies, a new direction in machine translation—hybrid machine translation—has emerged. Research and practical experience show that this approach makes it possible to improve the efficiency of machine translation systems. At present, hybrid models that combine linguistic rules and statistical data are used in machine translation systems developed within various public and private sectors to transform a source-language text into the target language.

There are several methodological variants for implementing the hybrid approach in practice. In some systems, a translation variant is first generated using a rule-based mechanism, and at the next stage the obtained result is edited, refined, or corrected on the basis of statistical data. In other models, linguistic rules are applied to the preprocessing of input data as well as to the post-editing stage of the output generated by a statistical translation system. Such an integrative mechanism is of particular importance because it expands the flexibility, controllability, and functional capabilities of the translation process.

Hybrid models that integrate several machine translation paradigms within a single system are receiving increasing attention in contemporary translation studies and computational linguistics research. In particular, the METIS-II machine translation system can serve as an example of a hybridization model based on the EBMT concept. This system reduces the need to use parallel corpora, which are generally required for EBMT, and instead uses a bilingual dictionary typical of rule-based machine translation systems and monolingual corpus data in the target language [4]; [5].

Another model of hybridization within the rule-based paradigm is based on integrating statistical methods into an RBMT system. In this case, the most appropriate translation variant is identified according to statistical criteria from among several alternative translation hypotheses generated using rule-based algorithms. As a result, the structural precision of linguistic rules is combined with the probabilistic capabilities of statistical modelling.

Research Discussion. In the study of statistical machine translation, a number of linguistic, statistical, and technological problems are identified. One of them is the problem of sentence alignment. In parallel corpora, a single sentence in one language may be expressed by several sentences in another language or, conversely, several source sentences may be combined and translated as a single target sentence. Statistical methods such as the Gale–Church sentence alignment algorithm are used to determine correspondences between such units.

Another important problem is related to statistical anomalies. In a training corpus formed from real linguistic data, the excessively high frequency of certain constructions may lead the

translation system to draw incorrect statistical conclusions. For example, if the phrase train to Paris occurs very frequently in the training corpus, the sentence I took the train to Berlin may, under the influence of statistical predominance, be incorrectly translated with the meaning I took the train to Paris. This situation demonstrates the excessive dependence of the statistical model on frequency indicators in the corpus rather than on contextual meaning.

Data dilution is also one of the characteristic problems of SMT systems. This phenomenon is observed in the process of developing a new statistical translation model for a particular terminological domain, corporate brand, or specialized discourse. If the volume of a domain-specific or brand-specific corpus is insufficient, training data obtained from other sources are used to supplement it. As a result, an excessive amount of external data may reduce the statistical weight of domain-specific terminology, lexical choices, text format, and stylistic features in the model. This, in turn, may lead to a decrease in terminological consistency and stylistic adequacy.

The translation of phraseological units and idioms is also a separate research problem. The ability of an SMT system to adequately interpret idiomatic units depends primarily on the composition, size, and representativeness of the training corpus. If a particular idiom and its functional equivalent are not sufficiently represented in the corpus, the system may translate the unit literally or in a semantically inappropriate manner.

In EBMT methodology, the translation process comprises four main functional stages: collecting translation examples, creating and managing an example database, applying relevant examples in the translation process, and synthesizing the final translation variant. The theoretical basis of this approach is the concept of analogical translation. In this case, the translation of a new linguistic unit is generated by identifying similar translation examples previously entered into the system, analysing the structural and semantic relations between them, and adapting existing translation solutions to a new context [6]. Thus, example-based machine translation is an approach aimed at translating new texts on the basis of analogical modelling by using previously established parallel translation examples as an empirical knowledge base.

Ingliz tili	Ibo tili
How much is that red shoe?	ego one bu akpukwu ododo nu
How much is that small camera?	Ego one bu obele kamera na.

Table 1. Example of a Bilingual Corpus

Bilingual parallel corpora are used to train Example-Based Machine Translation (EBMT) systems. As shown in the table above, such corpora contain pairs of parallel sentences consisting of a sentence in one language and its translation into another language. This example demonstrates the principle of a minimal pair, in which the sentences differ from each other by only one element [7]. Such parallel constructions considerably simplify the process of identifying translation correspondences between linguistic units smaller than a sentence, studying their structural and semantic features, and developing translation models.

Figure 1. Architecture of the rule-based machine translation (rbmt) approach

Nº	English Term	Uzbek Translation	Description of the Process
1	Source text	Manba matn	Text entered into the translation process as the initial input.
2	Morphological analyser	Morfologik analizator	Identifies the morphological structure, grammatical forms, and categories of the words in the source text.
3	Part of speech tagger	So'z turkumlarini belgilovchi modul	Automatically identifies and assigns the appropriate part of speech to each lexical unit in the text.
4	Lexical selection	Leksik tanlash	Selects appropriate lexical equivalents for translation based on context and linguistic rules.
5	Structural transfer	Strukturaviy transfer	Adapts the grammatical and syntactic structures of the source language to the structures of the target language.
6	Lexical transfer	Leksik transfer	Transfers lexical units of the source language into their corresponding equivalents in the target language.
7	Morphological generator	Morfologik generator	Generates the required grammatical forms of words according to the morphological rules of the target language.
8	Post-generator	Post-generator (yakuniy generatsiya moduli)	Brings the generated translation units into their final form in accordance with the orthographic, morphological, and formal requirements of the target language.
9	Target text	Maqsad matn (tarjima matni)	The final translated text generated in the target language as a result of processing through the RBMT system.

Example-Based Machine Translation is considered a promising methodological approach because it reduces the need to manually develop linguistic rules in the translation process. At the same time, this technology requires the availability of analysis and generation modules that form the example database and generate the dependency trees necessary for analysing the linguistic structure of input sentences. Another important problem of EBMT systems is related to computational efficiency, and this issue becomes particularly relevant when processing large-scale databases [8]. Parallel computing technologies can be used to optimize this problem. Conclusion. In general, in hybrid machine translation models widely used in contemporary practice, the integration of rule-based and statistical approaches, in particular, plays an important role. A number of scientific studies based on the combination of these two paradigms have been conducted, demonstrating the possibilities of integrating the structural-semantic capabilities of linguistic rules with the data-driven mechanisms of statistical modelling within a single translation system.

The results of studying modern machine translation technologies from the perspective of linguistic analysis and hybrid models show that machine translation is a complex scientific and technological field based on the integration of artificial intelligence, computational linguistics,

and translation studies. The multilayered structure of natural languages, the polysemantic nature of lexical units, the various interpretations of syntactic constructions, the context-dependent nature of semantic-pragmatic relations, and the necessity of taking extralinguistic knowledge into account determine the main linguistic problems of the automatic translation process. The analysis of modern machine translation approaches shows that each model has its own functional and linguistic limitations along with certain advantages. Therefore, rather than relying on the capabilities of a single approach, integrating their effective aspects is considered one of the promising directions for improving machine translation. By combining different translation mechanisms, linguistic rules, corpus data, and intelligent algorithms within a single system, hybrid models make it possible to reduce semantic ambiguities, strengthen contextual correspondence, and expand the possibilities for the optimal selection of translation variants. In general, the further development of modern machine translation technologies is directly related to the deeper integration of linguistic knowledge with the capabilities of artificial intelligence, multilevel contextual analysis, and the improvement of hybrid models. Such an approach serves to ensure not only formal linguistic correspondence in machine translation, but also semantic adequacy, pragmatic correspondence, and terminological accuracy. Thus, the integration of linguistic analysis and hybrid models can be regarded as an important scientific and practical direction for improving the efficiency of modern machine translation systems, achieving quality indicators close to human translation, and expanding the possibilities of using automatic translation in various communicative and professional fields.

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