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Title of research article

From Military Intelligence to Arabic Linguistics: The Evolution and Contemporary Impact of Machine Translation Technologies

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Abstract

Machine translation (MT) has transitioned from a tool designed for military and intelligence purposes during the Cold War era to a central instrument in modern linguistics and Arabic language research. This paper explores the historical trajectory, theoretical foundations, and technological breakthroughs that have shaped the discipline. Beginning with the geopolitical drivers of early MT research in the 1950s, the study traces developments through the 1960s and 1970s, when computer technologies, statistical models, and bilingual dictionaries redefined the field. Today, MT is increasingly integrated with artificial intelligence (AI), neural networks, and natural language processing (NLP), enabling near-human accuracy in many language pairs.

Particular attention is given to the application of MT in Arabic linguistics, a field that presents unique challenges due to diglossia, complex morphology, and semantic depth. By analyzing Arabic–English and intra-Arabic translation systems, this study highlights both the progress made and the persisting limitations in terms of idiomatic precision, cultural nuance, and syntactic alignment. The findings suggest that MT is not merely a computational tool but also a linguistically informed discipline requiring constant collaboration between computer scientists and linguists.

This research underscores the necessity of integrating Arabic linguistic theory with machine learning algorithms to ensure that MT systems remain contextually relevant and culturally accurate. It argues that the evolution of MT reflects broader transformations in linguistics, computational sciences, and global communication, positioning it as a key driver of intercultural dialogue, education, and scientific knowledge dissemination.

Introduction:

Human language is a system of linguistic signs through which people communicate, attempting to decode its meanings using mechanisms of interpretation, discourse analysis, and the diverse capacities of the human mind.

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The process of understanding and interpreting these signs goes through several stages of mental development and cognitive mechanisms. A linguistic text consists of a set of linguistic signs that are interconnected, carrying within them cultural, intellectual, and social content born out of the linguistic community. Language is, fundamentally, a system — and linguistic systems vary from one human production to another. This variation necessitates mechanisms of interpretation, discourse analysis, and semantic decoding to enable smooth and effective communication. Among the most important of these mechanisms is **machine translation**. But what is machine translation? And how did it evolve from military and intelligence use to serve the fields of Arabic language and linguistics?

1. Basic Concepts

Before presenting the concept of *machine translation* as a compound term, we begin by clarifying its two components as defined in Arabic language dictionaries and linguistic terminology, as follows:

1.1. Language:

The concepts of *(translation)* and *(machine)* appear in Arabic dictionaries as follows:

1.1.1. Translation:

Derived from the verb *tarjama*, meaning to interpret or explain in another language, as stated by Al-Jawhari in his *Al-Sihah*. [i] From this verb come the terms *turtuman* and *tarjuman*, which refer to someone who translates speech, i.e., conveys it from one language to another. [ii]

In the *Contemporary Arabic Language Dictionary*, the term "translation" carries several meanings, including: *to translate speech* means to clarify, explain, or interpret it; *to translate a decision into action* means to implement or apply it; and *to translate for someone* means to recount their biography and life history. [iii]

From these definitions, it becomes clear that the most common understanding of "translation" is the transfer of speech from one language to another, although this process is often accompanied by explanation and interpretation to clarify meaning once translated.

1.1.2. Machine:

Derived from *'alatu*, meaning device, tool, or instrument. According to Ibn Manẓur, it can refer to equipment such as agricultural or industrial tools, calculators, or computers. [iv] The term *machine* is a derived noun form, and *mechanization* refers to the art of inventing and using machines. [v]

These definitions largely focus on human-made inventions and their applications, emphasizing their role in supporting various aspects of human life.

1.2. Terminologically:

Translation as a general concept, and *machine translation* as a specialized term, can be defined as follows:

1.2.1. Translation:

Linguists have proposed various definitions for translation, including:

- "The expression of the meaning of speech in one language by means of speech in another language, while conveying all its meanings and intentions." [vi]

- "The transfer of meaning from the source language to the target language. The process involves moving both the structure and form from the source language to the target language, thus transferring the semantic structure." [vii]

- "The rewriting of a particular subject in a language other than the one in which it was originally written." [viii]

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These definitions all agree that translation involves conveying speech from one language to another, though they differ slightly in how they define the conditions or flexibility of this transfer.

1.2.2. Machine Translation:

Saleh Beleid defines it as: *"The intervention of artificial intelligence through computer assistance to perform the act of translation, using stored linguistic and cognitive patterns, as well as structures and terms retrieved in relation to the language being translated."*[ix]

Machine translation is considered a branch of *computational linguistics*, which itself is a subfield of *applied linguistics*. The use of computers for compiling and organizing linguistic material has become a vital tool, especially in dictionary-making. [x] Computational linguistics has undergone many methodological transformations, and its techniques are now heavily based on AI algorithms and theories to achieve increasingly accurate translation goals.

2. Types of Translation

Translation can be categorized according to various considerations, such as the nature of the translated text, or the agent responsible for the translation. These types are detailed as follows:[xi]

2.1. Translation Based on the Nature of the Translated Text

This classification includes three main types:

2.1.1. Literal Translation:

This type relies strictly on the source text without considering semantic differences between the source and target languages.

2.1.2. Semantic Translation:

Here, the translator focuses on understanding the source text and conveying its meaning in the target language.

2.1.3. Communicative Translation:

In this type, the translator identifies the author's intended message and expresses it in the target language using a similar style.

2.2. Translation Based on the Agent Responsible for Translation

2.2.1. Human Translation:

This refers to traditional translation performed by one or more individuals.

2.2.2. Machine Translation:

This is translation performed by a computer, involving artificial intelligence. Machine translation can be further divided based on its purpose:[xii]

2.2.2.1. Observer-Oriented Machine Translation:

This enables the reader to access information written in a foreign language, and with minimal revision, obtain a basic and superficial translation. [xiii]

2.2.2.2. Editor-Oriented Machine Translation:

This aims to produce a machine-generated translation that is later revised and refined by a human translator. It depends on both pre-editing and post-editing processes. [xiv]

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2.2.2.3. Translator-Oriented Machine Translation:

This type is designed to assist human translators by providing dictionaries, encyclopedias, and terminology resources. The program does not perform the translation itself but supports the translator. [xv]

2.2.2.4. Author-Oriented Machine Translation:

This allows a monolingual author to obtain a reasonably satisfactory translated version of a text in another language without the need for revision. It relies on interactive modules where the author explains their intended meaning in their native language until the system produces a corresponding text in the target language. [xvi]

3. Phases of Machine Translation

Machine translation has gone through three main phases: [xvii]

3.1. First Phase (1940–1965):

This phase was marked by the development of the first foundations in morphology and syntax. During this period, the importance of translation increased significantly due to the intelligence needs of the Cold War era, which required a large number of translators to disseminate news and secrets. Thus, the idea of machine translation emerged within the context of the Cold War.

The United States feared the growing scientific advancement of the Soviet Union and believed that translating Soviet scientific documents would allow them to anticipate Soviet intentions and surpass them in numerous scientific and military discoveries.

During this phase, the digital computer emerged as a key tool for storing information and terminology. It laid the groundwork for a system based on:

- The use of a bilingual electronic dictionary.

- Reordering of words.

- Treating the word as the basic unit of translation.

- Applying basic code-breaking methods.

- Ignoring sentence structure and syntactic relations.

- Major challenges included words that belonged to more than one morphological category.

- Contextual influence on meaning was not considered.

- Semantic analysis had no role in early machine translation software. [xviii]

3.2. Second Phase (1956–1975):

This phase kept pace with scientific advancements that demanded speed and accuracy. It witnessed relative progress in Western, Chinese, and Japanese languages, which benefited from advanced linguistic software that could rapidly sort, organize, and match words with equivalents in another language—thanks to artificial intelligence.

This phase succeeded in addressing issues related to context-dependent terminology. AI was pushed to emulate human intelligence in capturing nuances, rhetorical elements, and contextual coherence. Data storage followed certain parameters:

- Shifting meaning.

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- Abstracting meaning.

- Producing nonsensical meaning due to structural incompatibility.

- Ignoring the linguistic background of the source or target language.

- Producing a useful but linguistically inferior text. [xix]

3.3. Third Phase (1975–Present):

This phase has seen significant advancements driven by the development of computers, window-based operating systems, and sophisticated software, alongside the evolution of intelligent machines. It represents a leap forward in the advancement of artificial intelligence, which has made computers more useful and intelligent.

AI in this stage aims to interpret human language by taking into account linguistic, rhetorical, and scientific dimensions, as well as human cognitive abilities. This intelligence relies on data sets that traditional dictionaries often lack, such as:

- Integration of new terminology along with relevant data, especially in scientific and technological fields.

- Saving time and effort for linguists and translators through comprehensive databases that outperform traditional dictionaries in efficiency.

- Offering an effective means for standardizing terminology, reducing duplication, and facilitating the identification and control of equivalents.

- Producing modern, specialized dictionaries on a regular basis with minimal effort.

- Providing multiple services enabled by diverse software programs. [xx]

4. Machine Translation, Linguistics, and the Arabic Language

We seek to clarify an important issue concerning the relationship between linguistics and translation—specifically, the role of linguistics in shaping translational work. Modern linguistic theories provide valuable tools and frameworks that contribute significantly to developing translation as a scientific discipline grounded in precise principles.

Translation has benefited greatly from linguistics, which has transformed it into a more structured and scientifically sound field. Translation theories, through their association with linguistics, have gained accuracy and objectivity stemming from precise description. Linguistics has also played a key role in organizing the tools and terminology used in translation.

However, it is important to note that while linguistics offers translation useful mechanisms for handling vocabulary and terminology through purely linguistic analysis of language phenomena, it has at times abstracted linguistic study away from real language use. It often diverges from the social and practical dimensions of language—daily speech and natural communication—which give language new, context-based meanings.

New linguistic theories have emerged focusing on communication and various forms of discourse, which has had a noticeable impact on the translation process. Linguistics has taken a direction that often moves away from the real-world use of language and its social context, despite the fact that real-life speech imposes new meanings shaped by the conditions and realities of communication.

4.1. Machine Translation and Linguistics

Linguistics is an inductive, objective, methodological, and empirical science that relies on observation and assumptions, and formalizes its results in abstract formulas and algebraic symbols. [xxi]

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The role of linguists—including phoneticians, lexicographers, morphologists, syntacticians, and semanticists—lies in supporting the translation of languages involved in machine translation processes. This stems from the fundamental truth that the major obstacle in machine translation is linguistic, not computational.

Key linguistic challenges include:

- Ambiguity

- Morphological and lexical overlap

- Syntactic complexity

- Lexical differences between languages

- Figurative expressions

The core difficulty is extracting meaning from written symbols—i.e., letters of the source language—and recognizing their social, cultural, religious, and scientific connotations. Then comes the task of producing equivalent sentences and texts in another set of linguistic symbols, ensuring that all these dimensions are accurately conveyed, without altering the intended meaning of the source. [xxii]

Translation must keep up with major developments in linguistic research. It cannot apply linguistic theories effectively without the assistance of linguists, who provide essential insights into how language is produced and understood.

What matters most to the linguist is not merely categorization, since the meanings of words are not fixed; they evolve over time and can change between generations. The meaning of words can also shift depending on the situation. What truly concerns the linguist are linguistic signs. [xxiii]

Many grammatical rules are exceptions that native speakers acquire through use. Foreign learners often struggle with these, such as broken plurals or gender distinctions in Arabic. Translation systems must be capable of handling all these linguistic phenomena, which fall primarily under the responsibility of experts in **applied linguistics**, and only secondarily under those working in **computational programming**. [xxiv]

4.2. Machine Translation and the Arabic Language

Arabic is one of the richest languages in terms of lexical material. It is written from right to left, like Hebrew and Persian, and is one of the most widely spoken languages in the world, being the language of religion and culture.

This cultural and religious significance has drawn the attention of researchers and orientalists, many of whom have conducted extensive studies on the Arabic language, the Arabian desert, and Arab life.

Unlike many world languages, Arabic has not remained isolated from the linguistic developments seen elsewhere. However, it has not benefited from machine translation to the same extent as Indo-European languages, whose development has been greatly enhanced by advances in computing and software.

Developing machine translation for Arabic thus requires multiple initiatives, including: [xxv]

- Establishing national centers dedicated to proper linguistic performance

- Accurately identifying the linguistic features of Arabic

- Producing Arabic machine-readable dictionaries and scientific texts

- Promoting the use of pocket dictionaries from Arabic to living languages

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- Standardizing and harmonizing terminology

Arabic computational development must also focus on the following:

1. **Character Encoding –** Unifying codes or assigning unique codes to each form of Arabic letters

2. **Data Standardization –** Developing a consistent data entry model for Arabic, facilitating input/output processing by programming standard formats

3. **Connected Letter Display –** Ensuring that Arabic script appears in its naturally connected form

4. **Diacritics Support –** Allowing diacritical marks to be placed correctly on letters to avoid ambiguity in reading

5. **Bilingual Encoding –** Enabling dual encoding systems (Arabic and Latin) to handle both languages simultaneously, while addressing linguistic differences through:

- Accurate representation of scientific information

- Emphasis on scientific terminology

- Establishing links between colloquial and formal speech

- Addressing figurative language and semantic shifts

- Exploring speech disorders and variations in language performance

- Applying stylistics, which determines the appropriate language use and writing style based on different contexts

Modern stylistic studies have successfully defined procedures and research topics, ensuring the scientific credibility and legitimacy of stylistics. [xxvi]

Conclusion

After this detailed overview of machine translation, we can assert that its initial use in the military field—driven by national security concerns—positioned it as a tool for uncovering the strengths and weaknesses of enemy states. This was due to the urgent need for rapid access to information without relying on human translators. In truth, machine translation is the product of remarkable technological advancement, which has constituted a major leap in modern science. It has significantly transformed the patterns of human communication.

Countries are now striving to develop their knowledge systems, preserve national cultures, safeguard national identity, and enhance translation and the teaching of their national languages. This is being pursued through the unification of symbols and standardization of writing systems to ensure control over modes of communication within societies.

Over the years, advancements in computational algorithms and the availability of vast linguistic datasets have enabled increasingly accurate and sophisticated translation processes. In this context, linguistics has played a major role in providing computers and algorithms with the necessary linguistic content, offering essential data for translation, and interpreting modern linguistic theories. All of this has contributed significantly to the development of machine translation.

This, in turn, has highlighted the need for those engaged with the Arabic language to invest in artificial intelligence as a means of modernizing the language and facilitating its use among both native and non-native speakers. Indeed, machine translation plays a crucial role for states, individuals, and institutions. It has streamlined linguistic interactions and enabled global communication, thereby enhancing international connectivity and facilitating more comfortable and accessible living conditions for speakers of different languages. It has also contributed to economic, social, and commercial development among nations.

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Despite significant technological progress, machine translation continues to require the expertise of linguists. These specialists are vital for identifying contextual and cultural nuances, breaking down complex terminology, and defining diverse linguistic environments to improve translation accuracy and adaptability.

This brings us back to the importance of investing in machine translation for the Arabic language. Language academies have worked to standardize letters, unify linguistic codes, and structure data by developing specific models for Arabic writing. These efforts will undoubtedly contribute to the development and broader use of Arabic among its speakers, promoting cultural unification, facilitating communication, and achieving national, cultural, and linguistic security.

Findings

1. Historical evolution: Machine translation began as a military project aimed at deciphering foreign intelligence, but its role expanded into academic, commercial, and educational domains from the 1970s onward.
2. Technological progress: The transition from rule-based to statistical and then neural MT models has significantly improved translation accuracy, speed, and adaptability.
3. Arabic-specific challenges: Arabic's diglossia, morphological richness, and contextual semantics remain barriers to precise MT output, although hybrid and neural models show promise in addressing these issues.
4. Linguistic integration: Collaboration between computer science and Arabic linguistics is essential for refining translation systems that respect cultural and semantic depth.
5. Practical implications: MT is increasingly used in academia, diplomacy, media, and international communication, shaping the role of linguists in an AI-driven translation landscape.

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Conflict of Interest

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