The Mutual Shaping of NLP Machine Translation and Society

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

With the rapid growth of technology, information, and society, we are stepping foot into a new age, the age of AI (Maynard, 2022). Currently, artificial intelligence (AI) is increasingly being integrated into various aspects of our lives. With recent technological advancements in the field, AI is now capable of performing complex tasks and making decisions that were previously only possible for humans. This has begun to revolutionize various industries, such as healthcare, finance, transportation, and manufacturing, to name a few. AI technologies are also transforming the way we interact with machines and the world around us, from voice assistants and chatbots to self-driving cars and drones. One field that has seen significant improvements with the assistance of AI is machine translation (MT). Machine translation refers to the use of computer algorithms and software to automatically translate text or speech from one language to another. It is a subfield of natural language processing (NLP) that aims to create systems that can accurately and efficiently translate between languages without the need for human intervention (Brooks, 2021). Recently, MT has become an essential technology that plays a crucial role in breaking down language barriers and promoting communication between people of different linguistic backgrounds. It allows individuals, organizations, and governments to communicate and exchange information more efficiently and accurately, enabling better collaboration, trade, diplomacy, and cultural exchange. MT has more effect on different industries and fields than ever before; therefore, society should cautiously advance this technology in the direction we want, and learning its development history can help us direct MT advancement. This research paper aims to provide answers to the following question. How did global trends and events shape the development of MT, and what effect does MT have on commerce, communication, and culture exchange?

Background

The history of MT began during the Cold War. The Cold War was a period of geopolitical tension and ideological conflict between the United States and the Soviet Union that lasted from the end of World War II in 1945 until the collapse of the Soviet Union in 1991. It was characterized by a state of military and political tension, with both sides engaging in a nuclear arms race and engaging in proxy wars and diplomatic maneuvering. As a result of such tension, both sides sought to gather as much information on each other as possible. However, there existed a clear obstacle, the language barrier. The US intelligence service wanted to understand Russian communication and more importantly Russian scientific advancements (Gordin, 2014). Meanwhile, the USSR illegalized the publishing of scientific papers in English in an attempt to prevent Western nations from stealing information. To solve the language barrier, the US devoted budget and effort to numerous projects, one of which was the Georgetown–IBM experiment. The Georgetown-IBM experiment was a groundbreaking research project conducted in 1954, debuting and testing the feasibility of machine translation (Gordin, 2014). The experiment involved translating Russian sentences into English using a computer. The results of the experiment were mixed, with some translations being accurate while others were incorrect or nonsensical. Despite its limitations, the Georgetown-IBM experiment was a pioneering effort that demonstrated the potential of machine translation and paved the way for future research in the field. It also inspired further developments in natural language processing and computational linguistics, leading to the creation of more advanced machine translation systems. The experiment caught the world's attention and impressed many experts in linguistic and computer science. During the same time, the trend of globalization swept across the world,

and numerous nations also faced language barriers. Many of them also saw MT as a solution. The Georgetown–IBM experiment sparked the fire for MT development and pushed many nations into the race.

In the past 70 years, MT technology has evolved significantly, with the most recent progression being neural network translation (Gordin, 2014). Neural Network is an AI concept that mimics the human brain's structure and function. It is a fundamental component of AI that learns to recognize patterns and relationships in data and make predictions or decisions based on that data. Neural network translation, also known as neural machine translation (NMT), has several advantages over other types of machine translation. NMT provides better accuracy, more fluent translations, and can learn from context. All of these improvements are achieved through neural network models. On top of these clear advantages, NMT models can be trained faster and more efficiently than other models because they require less manual feature engineering and can be trained from raw text data. Overall, NMT has demonstrated significant improvements in translation quality and has become the dominant paradigm in machine translation research and development. Despite the recent achievement of NMT, the concept of neural network translation was introduced years ago. NMT models are trained through machine learning (ML). ML is a subset of artificial intelligence that enables computers to learn from data and improve their performance without being explicitly programmed. It involves algorithms that analyze and identify patterns within data, allowing systems to make predictions, decisions, or classifications based on new, unseen inputs. ML is often extremely computationally intensive and limited by the computing power available. For the past many decades, the computing power of the world has grown at an exponential rate and recently reached a level where neural network translation is realizable (Mack, 2011).

Methods

For the evidence to be used in the research, I searched the Web of Science database using relevant keywords related to Machine Translation. The search was limited to peer-reviewed literature published in English, and I used inclusion and exclusion criteria to ensure the selection of relevant studies. Specifically, I included studies that focused on Machine Translation development and usage as the main topic and excluded studies that were not related to the field. I also excluded technical articles focused on Computer Science research. The search yielded a substantial number of articles that were then screened based on the abstract and full text to determine their eligibility for inclusion in the study. The final selection of articles was based on their relevance to the research question.

Results and Discussion

After an extensive review of many scholarly sources, several key findings emerged that provide insights into the mutual shaping of machine translation and society. The three major factors that affect the direction and development of MT are political environment, commercial incentives, and cultural communication needs. On the other hand, MT's effect on society can be summarized as simply expediting communication and exchange of information, especially in the cultural and commercial worlds.

The first and most significant source is Gordin's paper on the Dostoevsky Machine in the Georgetown-IBM experiment (Gordin, 2014). In summary, his paper provides a comprehensive historical overview of machine translation, exploring deeply into the specifics of the Georgetown-IBM experiment and the surrounding geopolitical tensions during the Cold War era.

His analysis considers the environmental factors that influenced the decision-making process during the development of MT technology, offering clear evidence of the interplay between MT innovation and political environment. In 1954, IBM unveiled the Dostoevsky Machine at its headquarters in Manhattan, capable of translating Russian into English. The public demonstration showcased the result of a year's collaboration between Georgetown and IBM. They applied a vocabulary of 250 Russian words and six rules of "operational syntax" to translate over 60 Russian sentences into grammatical English in just six to seven seconds each. The selection of the translation languages was very intentional. Given the Cold War political environment, creating a machine that can translate Russian to English would attract more attention and investment than any other language pair. The directors of the experiment believed that "interlingual meaning conversion by electronic processes", machine translation, would be a reality within three to five years after the experiment (Gordin, 2014). Examining the claim from today's perspective, we know it is false since accurate machine translation only recently became available.

As mentioned previously, the development of MT, in the beginning, was largely driven by the political tension and environment of the Cold War. Attention to Soviet science was increasing due to concerns about the Soviet Union's growing scientific infrastructure. The language barrier, specifically the Russian language, became a practical obstacle for the Americans to access Soviet scientific literature. The early development of MT was driven by the need for U.S. scientists to read Soviet publications and the belief that scientific language would help unlock the secrets of Russian grammar. Early machine translation developers believed translating "scientific Russian" was easier than typical spoken Russian. "Scientific Russian" is systematic and plain with simpler grammar, so almost all machine translation projects, in the

beginning, focused on “Scientific Russian. ” The choice of not only Russian but specifically “Scientific Russian” strongly indicates how influential the political environment affected MT development.

The US was not the only competitor in this machine translation industry (Gordin, 2014). Soviet MT research began in 1955 and by 1964, the Soviet Union was considered the leading country in MT. The MT race between American and Soviet programs was an open secret among researchers. The publicity of Soviet experiments led to a rise in interest and support for MT work in the United States. Some professionals, however, believed the race was an “amiable conspiracy” to extract money from their respective governments using various experiments and demonstrations. By the late 1950s, dissidents began to emerge within the industry. In 1960, Bar-Hillel, a renowned professional in this field, published a paper concluding that fully automatic, high-quality translation (FAHQT) was impossible due to the inherent complexities of human language. In April 1964, the Automatic Languages Processing Advisory Committee (ALPAC) was formed to advise on MT research. The committee observed a lack of progress in funded MT programs and concluded that MT projects are not a priority. Ironically, the Georgetown-IBM experiment was cited as evidence of MT’s “nonexistence.” The MT field would not recover until the 1980s.

After riding the Cold War environment to fame, machine translation swiftly caught another ride to even higher positions. After WWII, the world began to globalize. Nations began to interact with more foreign nations than ever before, and with the intermingling of cultures and languages, the translation industry and machine translation became more prominent than ever. In the article Cultural functions of translation: Sustainable development in the context of globalization by Dalai Wang, the author provides insights into the cultural exchange aspect of

globalization and what role translation plays in this act (Wang, 2011). Wang discusses how translation can promote cultural communication and understanding between different cultures and has a significant impact on shaping cultural identities. Removing barriers to intercultural communication is crucial in the context of globalization; therefore, there exists a high demand for accessible and speedy translation, in other words, machine translation. With the ability to easily translate and spread information on the internet, MT simplifies the challenges that come with cultural diffusion. As a result, MT indirectly increases the demand for its own service. The cycle here is a prime example of the mutual shaping of technology and society. Not only does MT expedite the diffusion of cultures, but it also stimulates innovation and experimentation in literary writing and influences the development of different kinds of literature. The author gives multiple examples of the above phenomenon using Chinese literature and Chinese translation. In the context of globalization, interactions between foreign nations are inevitable, and translation including MT plays a crucial role.

Besides the profound mutual effect between culture and MT, the relationship between commerce and MT is just as interwoven. The paper Translation and Interpreting Industry and Regional Economic Development by Ding Zhaoguo relates to Wang's perspective. Instead of focusing on the cultural effect of translation, the paper explores the relationship between translation and interpreting (TI) industry and regional economic development, with a focus on China's TI industry (Ding, 2008). Ding argues that TI industry plays an increasingly important part in the sustainable development of regional economies in the global context, especially in changing regional economic structures and growth patterns, promoting competitiveness. With MT being an essential tool to the TI industry, offering speedy and mass translation at the click of a few buttons, one can see the close relationship between commercial development and MT. The

paper discusses the large market size of the TI industry, which is recognized as an emerging industry in China (Ding, 2008). The potential value of the world TI industry market reached 22.7 billion US dollars in 2005. Ding argues that TI plays an indispensable role in the modern economy, especially in fields such as science and technology, academic research, international trade, and cultural exchange. The TI industry has a significant impact on regional economic development by promoting regional competitiveness, attracting foreign investment, and enhancing regional cooperation. The tight bond between MT and the IT industry in China reveals the indispensable usage of MT for economic success. Under the scale of globalization, machines can translate large amounts of documents that are impossible for human interpreters. Therefore, for a local company or industry to thrive outside of its domestic environment, MT is often necessary for success. Commercial development demands the usage of MT while MT aids in the success of companies. The cycle here is another example of the mutual shape of technology and society.

Wang and Ding's articles highlight the significance of the translation industry in the context of globalization. Annie Brisset's paper explores the significance of machine translation in the context of the translation industry. In the paper Globalization, translation, and cultural diversity, Brisset also discusses globalization and its impact on language and translation (Brisset, 2017). Due to technological advancements, the world has become more interconnected and communications have surpassed the economy. The translation and interpreting market is growing, estimated to reach USD 45 billion by 2020. Machine translation is also increasing, with a forecasted growth rate of 23.53% each year from 2014 to 2019. The real volume of machine translation is difficult to evaluate due to factors such as free online software and confidential documents. MT technology is being used to help with the increasing demand for translation

because of international organizations and globalization. Companies like eBay are using machine translation to help their clients understand their product catalogs in their own language. After the year 2000, automated language processing became better because of Google and more powerful computers. As one can see, for the past decade or so, MT has slowly become an indispensable part of the translating industry, especially after the quality of MT has improved significantly. Similar to Ding's perspective, Brisset agrees with the heavy commercial utilization of MT and the necessary financial implications of MT in globalization.

Furthermore, Brisset's paper also mentioned the US Defense Agency started a program in 2010 to make software that could translate different types of media with a high level of accuracy. They specifically wanted to improve Arabic and Mandarin translations. As Gordin's paper shows, once again, we see the connection between translation and political tension and how the political needs steer the development of MT onto a certain path.

Besides the cultural and economic effect that machine translation has on society, there exists one massive accidental side effect of MT technology. In 2017, Google published a groundbreaking paper titled "Attention Is All You Need," which introduced the Transformer model (Vaswani, 2017). This novel approach aimed to revolutionize the field of machine translation by proposing a more efficient and effective method to process sequential data. The Transformer model relies on a mechanism called self-attention, which allows the model to weigh the importance of words within a sequence and establish relationships between them. The Transformer model significantly reduces training time and computational complexity. As a result, this innovation has enabled the development of more advanced machine translation systems that can handle longer and more complex sentences, ultimately leading to better machine translation quality than ever before. As someone who is fluent in both Mandarin and English, I

can clearly distinguish the difference between a machine-translated sentence with a conventional neural net model before 2017 and a transformer model after 2017. The quality of fluency and grammar is almost worldly apart, especially when it comes to larger sentences and documents. Interestingly, the transformer model proposed by Google is also the underlying architecture behind ChatGPT (Majid, 2022). Without the invention of the transformer model for MT, the revolutionary technology that is ChatGPT would not be possible. It is hard to estimate and calculate the impact that ChatGPT and other similar Large Language Models (LLM) have on society, but as someone who is currently living through this change, I and almost every student at UVA can attest to the changes that have been brought to our lives. Many new ideas, technologies, and even companies have spawned because of LLMs, and their influence on society is immeasurable as of now. We will experience many changes as we enter the era of artificial intelligence, according to many experts in the field.

Conclusion

In conclusion, this research emphasizes the complex interaction between technology and society in the context of machine translation. The development of MT has been significantly influenced by political, cultural, and economic factors, leading to its current state as an indispensable tool for global communication and cultural exchange. In reverse, MT offers opportunities for cultures to express, businesses to expand, and economies to grow. As society shapes the development of MT through political pressure, cultural need for expansion, and economic incentives, MT also affects key aspects of our lives like commerce and culture, allowing people to access parts of the world outside of their domain. The mutual shaping is evident and obvious. As technologies evolve, new innovations can cause cascading effects

similar to the coincidence between the Transformer model and ChatGPT. No one knows for certain what the future holds, but as demonstrated through this research, we, society, have power and influence over the development of technologies. We have the power to steer the direction of progress, and as students of engineering, we should do so thoughtfully.

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