

# A Survey Report on Evolution of Machine Translation

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**Abstract :** In this paper we describe a survey report on the evolution of Machine Translation. We have described case studies and evaluations of machine translation systems. The study provides several insight into the history of growth of Machine translation technology from the 1930's to the present 2010's. From the evaluations we observed that, there is an incremental growth in the quality of machine translation as well as the usage of machine translation systems. Moreover there is a tremendous amount of growth in machine translation technology over the past century.

**Keywords :** Machine Translation, Statistical Machine Translation, Rule-Based Machine Translation.

## 1. INTRODUCTION

### 1.1. The first steps of machine translation

The first proposals of machine translation idea – ideation – were made in 1933 independently by both French scientist George Artsrouni and Petr Smirnov-Troyanskii from Russia. Artsrouni has received a patent for a storage device on paper tape that could find the translation of a word in another language. However, their ideation did not find wide recognition as a society was not ready to adopt this translation technology. The world was being shaken by military conflicts, economic crisis, World War II, and social conditioned inventions were moved to background during this historical period.

During World War II, the number of new technologies was developed for military purposes including electronic computers in the USA. These achievements created new possibilities for applications in linguistic and machine translation. The first who introduced idea about use of computers for translation was director of the Natural Sciences Division of the Rockefeller Foundation Warren Weaver, mathematician, who had been involved in the projects of electrical engineering for military purposes.

During the first stage of development, the translation technology in scientific literature was named “mechanical translation”, though some researchers preferred to write “automatic translation” and “machine translation”. In early 1950s, the research activity in this field in the USA had begun at the Massachusetts Institute of Technology (MIT), the University of Washington (Seattle), and at the University of California (Los Angeles). The first full-time researcher in machine translation was appointed at MIT in 1951 – Yehoshua Bar-Hillel, who had originally come to the USA from the Hebrew University of Jerusalem. A year later the first scientific conference on machine translation have been organized in MIT where the machine translation was considered as a new field of cybernetic science with connections to linguistic.

After the two years of researches and experiments, the first demonstration of the machine translation prototype has taken place on January 7, 1954. The major American newspapers including the New York

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Times, New York Herald Tribune, and others have published reports about the first demonstration of a computer for translation text from Russian to English. The prototype was accepted by early consumers – military and intelligence agencies of the USA despite the limitations of machine translation and low fidelity of translated texts. The machine translation technology, mediated through computer technology and synchronous to the operation of supervening social necessities was in right place in right time [4], [5], [7], [8].

## **1.2. The high expectation and the first disappointment over machine translation**

After the first demonstration, the public opinion and non-specialists had very optimistic impression on possibilities of machine translation. The government of the USA was under impression as well and supported this technology to expand the capacities for translation of scientific and intelligence data on the Soviet Union. The main funding in the US in 1950-1960s was provided for researches in Russian-English translation, and the same happened in the Soviet Union where researches were concentrated on development English-Russian translation systems. The key principle of the first machine translation researches was word-for-word direct translation approach developed under the professor of Chinese Erwin Reifler at the University of Washington (Seattle) where was one of the centers of machine translations (MT).

However, the first generation of MT systems did not include solid syntactic analysis and grammatical correction and the output of machine translation was unreliable and ambiguous. The optimistic expectations after the first prototypes – “inventions” – did not find confirmation in the latest machine translation systems because of poor quality of translation and caused disappointment among main investors during that decade. As a result, the US government has established in 1964 a special committee for investigation and evaluation of the situation with the machine translation researches – the Automatic Language Processing Advisory Committee (ALPAC) of seven members.

The ALPAC has prepared in 1966 the crucial report, which returned a comment that “Machine Translation was slower, less accurate, and twice as expensive as human translation and that there is no immediate or predictable prospect of useful machine translation”. It recommended to government to suspend further investments in machine translation research and instead of that to concentrate on automatic dictionaries and basic researches. The impact of the report was deep and negative for machine translation school and inhibited many projects in this field in the USA for a decade. The U.S. government has put a “brake” on machine translation [1].

## **1.3. “The quiet decade” and a new commercial wave**

In Canada the researches have began in 1970 and was fruitful. The most known example of these efforts was the *Météo* – system for translating weather forecasts for English-French pair of languages. It was designed specifically for the needs of meteorological service and has been launched into operation in 1976.

Another achievement of that period included a project at Grenoble University for Russian-French translation that had different from the US researches approach. It was the second generation of translations systems based on interlingua. Interlingua plays a role of mediator between source and target languages that theoretically helps to improve syntaxes and grammatical structure of translated texts using linguistic methods.

During the 1980s the computer technologies were developing rapidly. That included development of the first personal computers that created opportunity for marketing machine translation systems among commercial consumers and the adoption of Optical Character Recognition (OCR). As a result, the machine translation market expanded and many new players entered to a market with their own products and tried to develop a market of civil technologies.

Since the 1980s, the big role in machine translation was played by Japan, where the computer technologies and software development raised with impressive speed. The Japanese considered translation as “necessary to their technological survival, but have found it extremely difficult – and expensive – to accomplish by human means”. Major consumers of these systems were in the export trade. Another

project was launched in Germany with financial support of the Siemens company – the METAL German-English system. It was not just machine translation engine but whole software package with text processor, dictionary, and database. China has launched own machine translation system CULT for mathematic texts in Chinese-English.

The largest MT project in the Western was Eurotra, which aim was to create a multilingual translation system for all languages of European Economic Community. Eurotra represents the second generation of machine translation as there was introduced idea of transfer approach which based on usage of interlingua between source language and target language. This project stimulated innovative researches in European countries but was unsuccessful in a result, as a working prototype was not produced.

The 1980s was period of commercialization of the technology and decreasing prices, machine translation companies have shifted focus from purely scientific matters to marketing and expansion in the market. The first microcomputer systems were launched on the machine translation market during 1980s. These systems were oriented to support human translation and did not provide full automatic translation of texts. The first commercial systems were developed in the USA and included Weidner and Automated Language Processing System (ALPS). These systems had limited success among consumers and afterward changed their mission or were acquired by other companies.

In the late 1980s, the development of machine translation was influenced by researches in natural language processing within the context of artificial intelligence (AI). It should overcome the problem with low quality and lack of fidelity in machine translation systems based on word-to-word or direct translation approach.

#### **1.4. Rise of new approaches in machine translation since 1990s**

In the beginning of 1990s, new methods and strategies of machine translation were emerging. An IBM group of scientist has published in 1988 the work on statistical methods that inspired many researchers to work in that direction. Mainly the wide adoption of this method was caused by increasing power of computers, memory capacity, and cheaper costs. The method was simple, it did not require use of linguistic rules, – computer aligns phrases and words in the parallel texts, and then estimates the probabilities that a word in a sentence of source language corresponds to a word in the target language sentence. The results of translation were acceptable as about half the text translated was similar to the source text.

The increase of scanners use and OCR software had urged the implementation of ‘example-based’ approach that afforded the finding of translation of phrase and words based on earlier translated texts. The high priority in research during that period was given to improvement of quality of generated texts in target languages. The rising computer industry in Japan had opened new opportunities for development a market of terminal-based personal machine translation systems.

In addition to technological shifts, the political and social trends – the collapse of the Soviet Union has caused the end of Cold War and global economic shifts, which provided with new opportunities for transnational communication and simultaneously emerging digital reports, legal documents in different languages. “More emphasis is being placed on the use of national languages in documents and systems”. This set of supervening social necessities created good socio-cultural conditions for the acceleration of machine translation use.

The main trend was dictated by racing Internet penetration in developed markets that marked new page in machine translation research. Vendors of translation software started change their business models to suggest systems for personal usage and online services, covering new segments. In 1996, there were more than 500 vendors of MT software for the personal computer worldwide, and they put out well over 1,000 products. It was the fourth generation of machine translation systems based on statistical approach or hybrids. The range of their products also was expanding to creation specialized and industry oriented systems (for financial companies, agricultural, manufacture producers etc.).

## 1.5. Localization

During the 1990s globalization has send new impulse – localization of products for foreign markets. The rise of localization industry reflected the expanding nature of globalization and later has broadened out to other markets as communications, multimedia, pharmacy. The localization has become the main engine and consumer of machine translation systems.

## 1.6. Online machine translation as a new market disruptive innovation

The first attempt to launch online machine translation was in September 1992 when CompuServe has announced providing with MT services for English-German languages to the registered subscribers. It was the first time when MT software was integrated in Internet website to translate posts on some forums from English to German and later to French. The two companies Digital Equipment Corporation and Systran Software Inc. launched on December 9, 1997, AltaVista Translation Service, the first online machine translation service in Internet [6], [9].

The fourth generation of machine translation was a new-market disruptive innovation – free, accessible, and more productive though with lack of the raw functionality of existing full-scale products. However, there were some problems in the adoption of machine translation technologies. The stage of first prototypes was followed by period of suppression. Demanding consumers reject the translation output of MT system because of low fidelity of translation and necessity of post-editing [11]. In addition, the most of users had high expectations of machine translation that certainly caused inevitable disillusionment by translation results and performance, and as a result, it suppressed new disruptive innovation.

## 2. THEORETICAL APPROACHES TO DISCUSS THE EVOLUTION OF MT STARTED IN 1930S – 2000S

There were three important innovation theories to describe the evolution of MT: the theory of supervening social necessity, the theory of disruptive innovation, and the hype cycles theory [3].

- The theory of supervening social necessity by Brian Winston presented in his book “Media technology and society. A history from the telegraph to the Internet” that considers innovation from socio-cultural deterministic point of view,
- The theory of disruptive innovation by Clayton M. Christensen who analyzes innovations in the framework of market competition paradigm in the book “Seeing What’s Next: Using the Theories of Innovation to Predict Industry Change”,
- The theory of hype cycles by Gartner Inc. that characterizes a life cycle of early technology adoption on markets.

### 2.1. Social implications of machine translation

The freer access to online machine translation tools has provoked many discussions among professional translators about possible implications for their community. From the beginning of 2000s, a number of researches were undertaken in the field of adoption of machine translation by translation community in different countries.

There were several reasons of suppression and low adoption of machine translation software. One of the reasons is that, the early commercial systems has required labor-intensive and time consuming process of transfer data from existing terminology collections to new systems. Education is one of the prospective fields for machine translation usage. Ana Nino (2008) described teaching and learning implications of MT in foreign language classes. Particularly, in some universities the students use MT for post-editing of translated texts to improve writing skills.

There are also opportunities to implement machine translation in news media. Some newspapers have implemented online machine translation to translate their content simultaneously without or with

limited editing in foreign language. The MT also has found recognition among the legal community and professional librarians, which created growing demand for information in their own language. Law librarians are trying to implement machine translation of laws, court decisions, legal information, from foreign languages into English.

From consumers' point of view, machine translation has two main goals: assimilation of information (translation for reading and comprehension of an idea) and dissemination of information (localization of documentation).

## 2.2. Hype cycle of machine translation

The evolution of the machine translation can be described using the Gartner's theory of hype cycle that characterizes the progression of an emerging technology from excitement through a period of disillusionment to an eventual understanding of the technology's relevance and role in a market. The period before 1960s was "the technology trigger" stage usually characterized by technological breakthrough, first public demonstration of laboratory prototypes that generates publicity and industry interest in an emerging technology. The 1960s represent "the peak of inflated expectations" when translation software vendors offering the technology increases and new companies enter to the market. These two stages presented on Figure1 as period of "Promising experiments".

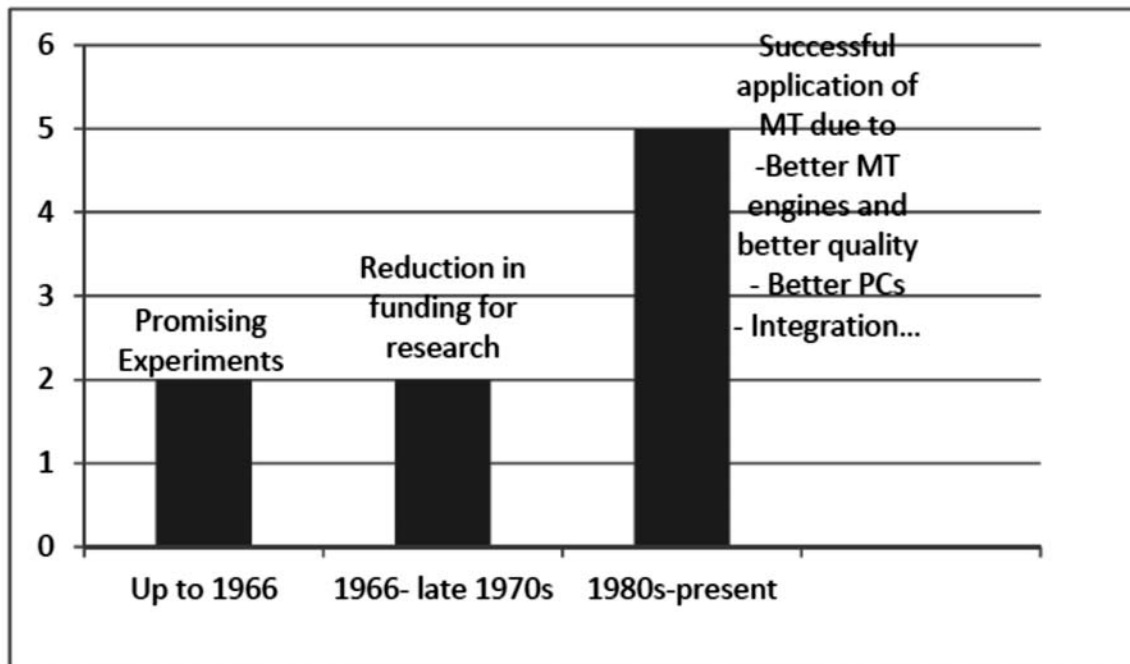


Figure 1: The Evolution of MT in the USA in the 20<sup>th</sup> century

The next period "Reduction in funding for research" in the late 1960s – 1970s was the stage of "the trough of disillusionment" that we mentioned earlier in case of the ALPAC and publicized failures of many MT companies. Beginning from 1980s the machine translation made step to the next stage.

According to Gartner, the machine translation in 2009 has placed on "the slope of enlightenment" stage (Figure 2). On this stage real-world experience by an increasingly diverse range of companies leads to a better understanding of the technology's applicability, risks, and benefits.

In 2009 the machine translation technology had only 5-20% of entire market. Gartner's analysts predict that the machine translations needs up to 5 years to enter "the plateau of productivity" stage that represents the beginning of mainstream adoption by majority of consumers, when the real-world benefits of the technology are demonstrated and accepted [7].

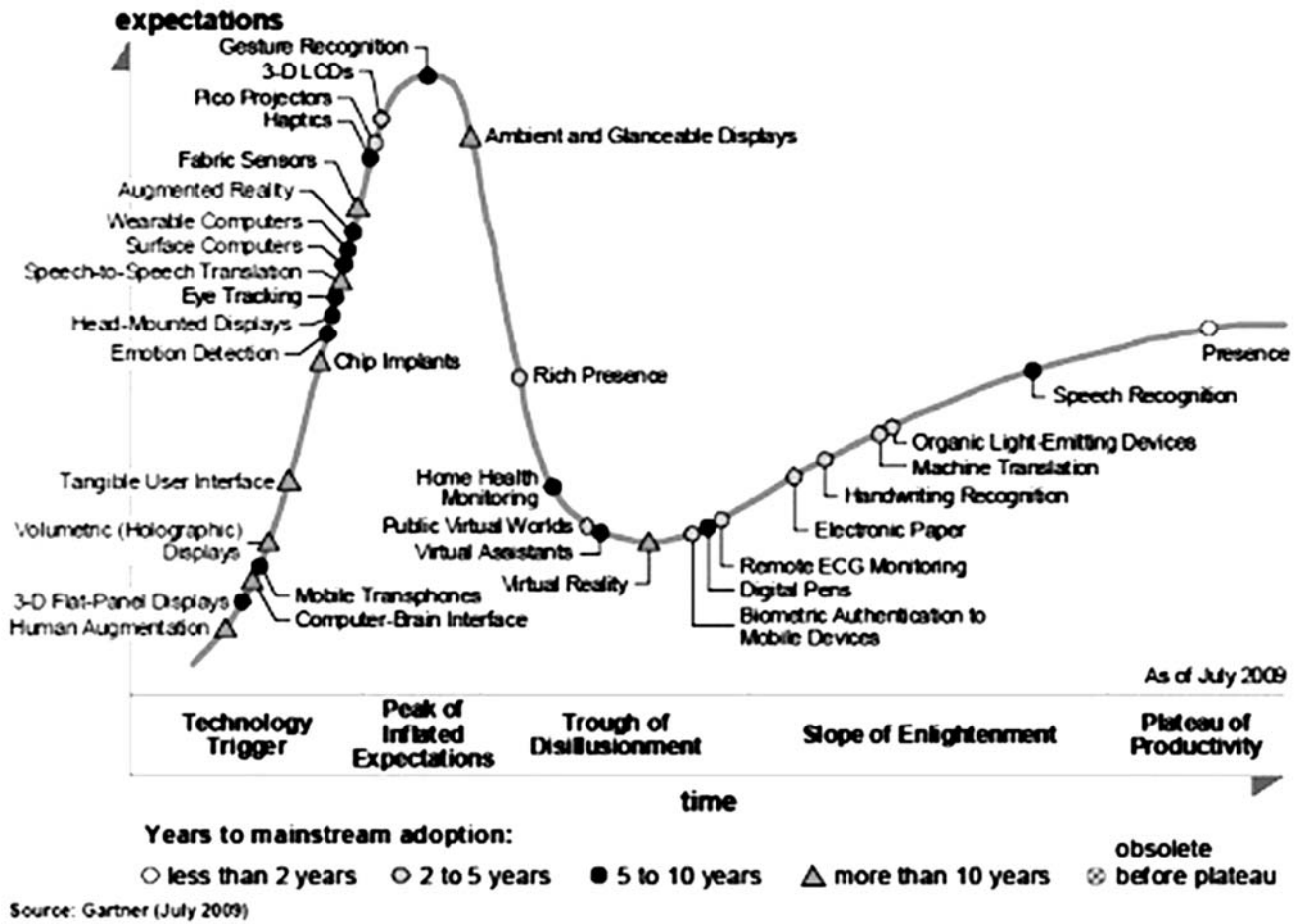


Figure 2: Hype cycle of machine translation in the 2000

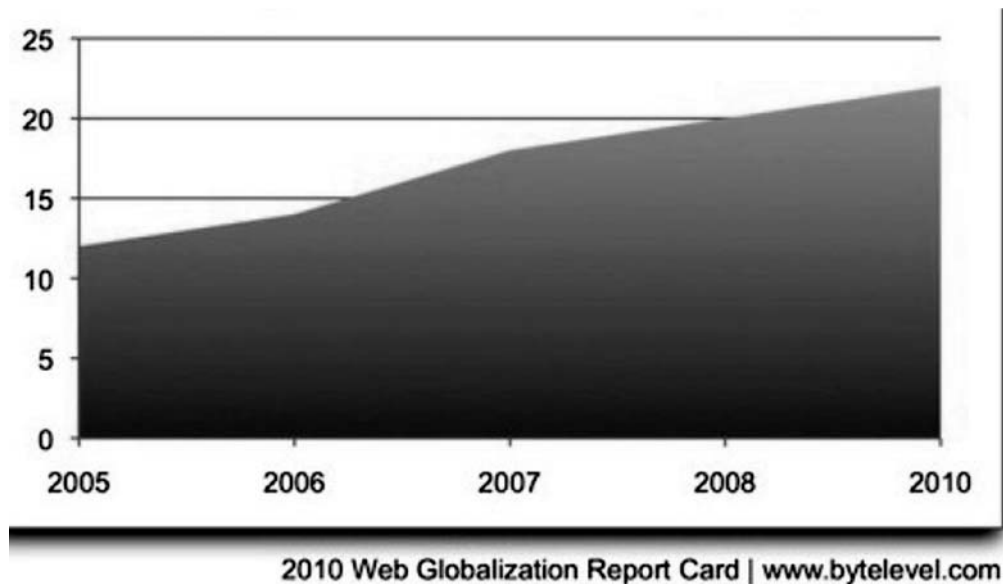


Figure 3: The average number of languages on global websites in 2010

The field of machine translation has seen major changes in the last few years. Currently a large amount of research is being done into statistical machine translation and example-based machine translation. Research has focused on moving from domain-limited systems to domain-unlimited translation systems in the area of speech translation. Solutions for automatically translating Parliamentary speeches and broadcast news have been developed in different research projects in Europe (like TC-STAR) and in

the United States (STR-DUST and US-DARPA-GALE). In these scenarios the domain of the content is no longer limited to any special area, but rather the speeches to be translated cover a variety of topics. More recently, the French-German project Quaero investigates the possibility of making use of machine translations for a multi-lingual internet. Figure 3 shows a graphical representation of the average number of languages on global websites in 2010 [8].

Today the market of MT is in maturity stage and incumbents – established companies like Google, Yahoo, Bing, Systran – are holding market and makes difficult entrance of new companies, which introduce improved performance compared to existing MT services. There has been a renewed interest in hybridisation, with researchers combining syntactic and morphological (*i.e.*, linguistic) knowledge into statistical systems, as well as combining statistics with existing rule-based systems.

In the last number of years deep learning models have made a significant impact across Machine Translation area of research. The development of the encoder-decoder architecture and its extension to include an attention mechanism has led to deep learning models achieving state of the art MT results for a number of language pairs. Which is the best attention mechanism to use is an open question in deep learning for MT. Moreover, neural machine translation is a recently proposed framework for machine translation based purely on neural networks.

There are several critical factors will influence the process of further development of new translation technologies [1], [2]:

1. Speed. Time is becoming more important indicator for online publishing. Translation also has to feel increasing pressure to produce information with less time.
2. Digital content. Internet has more media rich content that includes different audio and video content.
3. Cross-platform. The development of digital media is involves new platform and wireless devices. Therefore, translation should provide results that can be accessible via various platforms.
4. Quality. Despite the controversial quality of present machine translation systems, new demand will require high quality translation, particularly in e-commerce.
5. Pricing. Free online translation services are now most popular tools and it will create pressure for elaboration new commercialization models.

### 3. CONCLUSION

The new communication and Internet technologies of 21<sup>st</sup> century facilitate the increasing demand for the translation of information in different languages. The innovation that satisfies these social necessities is machine translation that already has 70 years history beginning from the first ideas in the mid-1930s until 2000s when disruptive online translation services are being widely accepted by public despite of the limitations of machine translation and low fidelity of translated texts. The machine translation technology, mediated through computer technology and synchronous to the operation of supervening social necessities has occurred in right place in right time.

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