A SURVEY OF MACHINE TRANSLATION IN THE FORMER USSR

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Abstract

The article covers the thirty year history of machine translation (henceforth MT) in the former Soviet Union. The author stresses the necessity of developing MT in view of the changing social and economic conditions of present-day life. MT is considered to be an efficient way of dealing with the substantial imbalance between the volume of incoming information and the human capacity to process it. Two types of translation are identified from a functional-communicative point of view, namely literary and specialised translation. The author specifies that in his view MT cannot be used for the translation of literary texts but only of administrative, technical and scientific texts, the domain of specialised translation. The Linguistic Translation Theory forms a theoretical background for specialised translation. Applied linguistics is based on The Linguistic Translation Theory, which it restructures and transforms for the needs of MT and Machine-Assisted Translation. The issues of applied linguistics are best identified in those areas where the beginnings of the theory and practice of MT are designed by joint teams of mathematicians and programmers, linguists and professional translators who work closely together. A description of such teamwork on MT strategies at the Moscow Institute of Exact Mathematics and Computer Systems in the 1950s and 1960s takes up the larger part of the article.

So far the technical equipment of a Russian translator, as well as the technical means for preparing and categorising papers and information, have been extremely limited. In fact there has been nothing but dictionaries and encyclopaedias, typewriters, stencils and hand-operated calculators. Nevertheless the number of papers and the volume of information which translators have had to process in administration and management have continually increased though the number of work hours has diminished. This has resulted in a substantial imbalance between the volume of incoming information and the human translators' capacity to process it. The efficiency of a man's work depends on his ability to process information rather than on his energy.

It follows that today effective management requires not only a skillful and multi-faceted use of the latest scientific and technological know-how, but also a radical change in the functions of humans in management systems. This can be brought about by dele-

gating part of the human workload to a machine. In other words, not by means of simple expansion of staff but by means of a complete or partial transference of some tasks to computers. The wide range of automatic means and the increased effectiveness of management processes depend on how successfully the problem of man's communication with a machine within the system 'man-machine' is solved. Linguo-statistical research, monolingual frequency dictionaries, information search systems, etc. serve for monolingual processes. Bilingual situations demand to be processed so that information is entered in one language and comes out in another. MT or Machine-Assisted Translation (henceforth MAT) is relevant in such cases.

MT and MAT systems may be polylingual, which is the case with a system equipped with machine thesauri in several source languages and several target languages, e.g. in systems which I shall call 'Translator's Automatic Workplace', and in the 'Automatic Terminology and Specialized Glossaries', as well as 'Machine Autonomous Branch Glossaries', etc. But in any such system the final result is determined by the contact of only two languages, that is, by the bilingual situation, even when the system itself is polylingual. Also, information processing may take place in situations of teaching polylingual communication with the aid of computers. In this case the information system is introduced in the classroom either in the source language or in the target language, or both in the source language and the target language. Specifically focussed systems, 'Teaching Machine Translation' would be an example.

I must make a slight reservation. In speaking about MT we are not referring to the translation of literary texts but exclusively to the translation of scientific and technical texts, at least this far. The amount of literary texts to be translated is relatively small. Only 30 thousand literary texts are translated per annum, whereas millions of articles, patents, instructions, etc. are translated, to say nothing of translational activities for the arrangement of international congresses, symposia, seminars, summits, formal and business meetings, negotiations and so on. Accordingly, literary translation is not the first concern in machine-based translation. Literary translation will, we believe, long remain the domain of talented people and not machines. However efficient computers may be,

they will not be able to master all the stylistic shades needed for rendering a literary source text adequately into a target language.

Translation from one language into another has existed since ancient times. Philologists from ancient Egypt, India, China, Arabia, Greece and Rome have translated religious and philosophical treatises. In Europe in the early Middle Ages and at the time of the Reformation there was a need to have the Bible translated into different national languages, and, during periods of formation of national literatures, translation came to be considered as an art in its own right. Starting with the sixteenth and seventeenth centuries up to the mid-twentieth century, the history of translation has been studied mainly if not exclusively as the history of literary translation.

No surprise then that the key statements traditionally accepted in Translation Studies were derived from writers and poets. Translation theory was taken to be a branch of Literary theory, and it is worth noticing that during the emergence of MT many critics and literary critics continued discussing its efficiency or inefficiency in relation to *literary translation.*

It was not until early 1950s that translation theory was acknowledged to be a part of linguistics. This became possible after a well-known discussion inspired by A. Fedorov's *Introduction to the Theory of Translation* (1953). The author made challenging statements about the linguistic approach as a fruitful and indispensable strategy in translation theory. The critical response pointed towards the unlicensed enhancing of linguistic input in translation. It was also a crucial starting point for linguistics' independence of literary theory (Nelyubin:1991).

There is a distinction between two types of translation from the functional-communicative point of view, namely Literary vs Specialised Translation. Literary translation is based on literary translation theory which embraces certain historical issues as well. Specialised translation covers the areas of communication of sociopolitical and administrative, as well as scientific and technical topics. The Linguistic Translation Theory forms a theoretical background for Specialised Translation.

Applied linguistics is based on the Linguistic Translation Theory which it restructures and transforms for the needs of MT and MAT (Nelyubin: 1983). It is no accident that the issues of applied

linguistics were first identified (and continue to be so) most successfully in those areas where the theory and practice of MT is developed by joint teams of mathematicians and programmers, linguists and professional translators.

Thus the priority given to the development of science and technology in the twentieth century brought about the growth in translation of specialised texts, oral as well as written. Given the rapid development of science and technology, the strengthening of international communication and growth of information, it is small wonder that translation has come to be central in today's world. This is most obvious in the necessity of processing more and more information.

By a conservative estimate, knowledge is doubled every 50 years. The volume of information, i.e. the data obtained in written, oral, or visual forms is doubled every 7 years. At a minimum, the volume of information therefore grows 50 times every 50 years. Today it is often more time-consuming and expensive to find an article or a report about some research than to carry out the experiment again. According to UNESCO, retrieval work in the libraries of the USA amounts to 300 million dollars per annum.

There are more than 50 million books in the Russian National Library in Moscow. This number is increasing annually with more than a million new books. Half the books kept there have never been opened by a reader. It is food for thought that the funds for the world libraries double every 15 or 16 years.

There are several million engineers and more than 500,000 researchers, among them 110,000 candidates of science and 12,000 doctors of science in Russia. Each of them needs data about developments in his specific field of research: lack of information forces scientists to reinvent the wheel. Nothing can stop science from developing. There are more than 400,000 scientific and technological journals in different languages in the world. Up to 4 million articles on science and technology, 200,000 book titles, about 450,000 descriptions, patents, copyright licences and hundreds of thousands of other scientific papers are published every year.

The information in English which enters Russia is increasing enormously. Thousands of translators are working in different institutions. Whatever their number, they cannot manage processing all the incoming foreign language information. The estimated standard

average output of a seasoned translator is eight pages of typed text per working day. Therefore the problem of increased information would not be solved even if additional tens of thousand of translators were asked to read, translate, and process information. International trade is also expanding. The growth of the cost of translation together with the vague perspective of raising the level of a translator's productivity explains the interest in MT.

It should be noted that MT and MAT could be (a) mechanized, (b) automatized, or (c) made fully automatic, depending on the technical facilities used. A mechanized system envisages the use of technical tools which would augment information processing. An automatized system envisages information processing based on structured steps with the help of computers and information technology, which would require minimum human assistance. An 'automatic' system would not involve human assistance at all. The existing lexical, grammatical, and semantic strategies of MT should be considered as stages towards making it automatic. But even in a unified system, all existing strategies can only bring about semi-automatic information processing in bilingual situations. A fully automatic system will presuppose that there is audio-visual input and output of the adequately received source information without human help. In its full meaning 'automatic translation' characterises the ultimate stage of machine use in translation, and this has not been achieved yet. What we have at the moment is automatic management and automatic and/or semi-automatic systems of processing information.

The first stage of mechanizing translation is the making of a dictionary. The first bilingual Latin-French dictionary dates back to 1498. The French-Latin dictionary by R. Etienne was published in 1539.

Older translators remember that before the emergence of MT and Machine-assisted Translation, MT was thought to be something like a mechanized dictionary. It was assumed that a translator encountering an unfamiliar word or word-combination could press a button and get the target language equivalent. But such a machine would have been useful only for those who know the foreign language well.

The first mechanized dictionaries were composed in 1924 in Estonia by A. Bachner, in 1933 in France by G. Artsrouni, and in

1933 in the USSR by P. P. Smirnov-Troyansky, who was also a pioneer in machine translation. Being a teacher of the history of science and technology, Smirnov-Troyansky handed in an application for his invention which he described as "a machine for the automatical production of complete printed translations in need of stylistic editing from one language into several other languages". He was given a certificate (No.40995) for inventing "a machine for selecting and printing words via translation from one language into the other", that is, for the first mechanized dictionary in the history of technology. It was a mechanical device which, from the vantage point of our electronic era, operated very slowly and therefore remained virtually unknown. Yet it should be acknowledged that Troyanski attempted to solve some linguistic problems in the automatic dictionary, though he proceeded from the assumption that the word-order was the same in all languages, and he suggested that a text should be translated word by word, and then undergo a process in which the words were given the proper grammatical forms, and the style was improved.

The glossary of Troyansky's machine comprised 60,000 lemmas. This was much when we remember that Leo Tolstoy used 12,000 words in his writings. All in all there are 180,000 lemma words in the Russian language and against some 200,000 in English.

What happened to the machine?

The story of Troyansky's invention is told by L. I. Zhirkov:

> "P.P.Troyansky-Smirnov who was an inventor and an engineer came to the department of the Academy of Sciences of the USSR in 1939 and announced that he had designed a device for MT from one language into another. He asked experts to evaluate his invention from a linguistic point of view. Linguists were very sceptical about P. P. Smirnov-Troyansky's invention. It was considered to be unrealistic and absolutely useless. There were very few who would accept the idea of machine translation. In a series of consultations which followed it became clear that the device for MT he designed... made it possible to have a Russian text translated, for instance, in Moscow and have it printed in French, for instance, in Paris. ...It was a long story. It ended in 1944 when a plenary session for experts in mechanics, electronic technology and linguistics was arranged at the Institute of Automatics and Telemechanics of the Academy of Sciences of the USSR. The surprising feature about the plenary was that specialists in mechanics and technology made a special point of arguing against machine translation. Getting into the intricacies of linguistics, they would discuss issues with no direct relation to their speciality. As a result an experimental model of the translation machine with a 1,000 word vocabulary was never constructed. As far as I know, P. P. Smirnov-Troyansky left Moscow soon after this event. I recently heard that he died in 1956."

Thus Troyansky's invention was rejected, because it was mechanical at a time when electronic technology was coming into being. Even the best ideas may seem to be ridiculous if they cannot be put into practice. But when they can, the same ideas are revived. The development of MT received a strong impetus by the practical application of computers whose main function was to process incoming information according to certain rules or algorithms.

The age of electronic technology began with the electric wire and radio bulbs. The first electronic device was designed in Germany in 1941 by the German engineer K. Zuze. It was named the Zuze machine after him. In 1944 the American specialist G. Ike constructed the first calculating machine, the programme operator Mark-I, which was electro-mechanical. The Zuze and Ike machines worked in the decimal system. In the USA J. Mauchi, still in 1944, designed the first computer, ENIAC, which worked in the binary system. In 1946 the mathematician Johann von Neumann (John von Neumann, since 1931 professor in USA) defined the main principle of modern computers. The most essential feature is the way information is stored. You could put not only the numbers but also the programme into a computer's memory. In 1946 W. Weaver, American scientist and co-author of *Mathematical Theory of Communication* (Shannon and Weaver: 1949), discussed the practicalities of machine translation, and in 1947 he contacted N. Wiener, an expert on cybernetics and a polylinguist who, at that time, was working on the book, *Cybernetics or Control and Communication in the Animals and the Machines* (Wiener: 1948).Wiener did not support the ideas. He doubted that "it would be possible to enter a full glossary into a computer's memory", to say nothing of the adequate translation of words with all their connotations. He believed "the mechanisation of language" and "mechanical way of translation" to be preposterous.

In 1948 Weaver learnt from J. Bernal about A. Booth's work on composing a machine dictionary: the word stems were entered and the principle of grammatical analysis was being elaborated. The same year Weaver published his memorandum *Translation* in which he described his ideas about how to translate texts by means of a computer. He approached the issue of translation as a cryptographical problem. His ideas aroused a great deal of interest among scientists. In 1952 the First Conference on MT was held at the Massa-

chusetts Institute of Technology. It was attended by 18 American and British scholars. The issues of MT were also discussed at the Seventh International Congress on Linguistics that same year.

By then computers had already made considerable progress. Thus, Mark-I did one multiplication per 5,7 seconds and a division per 15,3 seconds. The first electronic IBM computer SSEC was able to do 100 sums per second and 50 multiplications per second. By 1953-54 the average speed of computers had reached ten thousand operations per second.

The first attempt at MT from Russian into English was made on 7 January, 1954 in New York on the IBM-701 computer. It was carried out by a team of scientists from the Institute of Languages and Linguistics of Georgetown University headed by L. Dostert. The programme was designed by P. Sheridan. There were 6 translation rules and a 250-word vocabulary in the experiment. The vocabulary was extracted from 60 simple Russian phrases corresponding to e.g. "Processing improves the quality of petroleum", and "The international situation is an important factor in solving political issues". Although some of the Russian words were given two meanings and certain nouns were entered with several declensions, the machine came up with sixty sentences in pidgin English. This experiment in Russian-English MT went down through MT history as 'the Georgetown experiment', or 'Dostert's experiment'.

The year of 1954 also saw the appearance of the specialist journal *Mechanical Translation.*

On 25 December, 1951, the first computer in the former USSR, MECM, designed 1947 at the Electro-Mechanical Institute of the Academy of Sciences of the Ukrainian SSR, was put into operation. In 1953 another computer, SECM, began functioning at the Institute of Exact Mechanics and Computer Systems in Moscow. These computers were designed by teams headed by S. A. Lebedev. Among the Soviet programmers were M. V. Keldyish and M. A. Lavrentyev. In 1954 a team of Soviet scientists, I. S. Mukhin, L. N. Korolyov and S. N. Razumovsky, working at the Institute, decided to concentrate on making MT work. They were prompted by the Georgetown experiment of which they learnt from the synopsis published. The idea was supported by Lebedev and D. Y. Panov who were appointed co-supervisors of the project.

The designers of the first Soviet MT strategy believed that MT posed linguistic rather than technical problems. It explains why, in January 1955, a very talented linguist, I. K. Bel'skaya, joined the team at Panov's recommendation. It took her less than a year to successfully carry out the linguistic part of the project. It became possible for several reasons. First, from the very start Bel'skaya rejected the popular idea of formalizing a language by means of mathematical methods analogous to deciphering techniques. Secondly, she made a special point of researching those linguistic layers of the text structure which would be used by competent translators. Her main idea was that it was possible to formalize linguistic analysis completely; this was in line with the idea aired much earlier by Troyansky and still disputed sometimes even now. Thirdly, Bel'skaya designed a working scheme for automatic analysis of English scientific-technical texts after she had analysed a vast material. Her scheme consisted of 25,000 steps. Thanks to this, a computer making about ten thousand operations per second could translate one phrase in the course of a few minutes.

In December 1955 the first computer-assisted translation from English into Russian was accomplished. It was a small part of Milne's book *Asymptotic Solutions of Linear Stationary Integra-Differential Equations.* The first English-Russian MT comprised 952 English words and 1073 Russian equivalents. The programme and the dictionary were open (adaptive) and self-regulating, which means that the system might be used for translating not only specialised texts from books on mathematics but also other texts for which the dictionary had to be enhanced. This experimental MT system was a great step forward in comparison to Dostert's device.

The team's initial steps were succeeded by the translation of a newspaper article according to the same scheme. This experiment was also successful, even better than the team itself had expected, as Panov recollects in his memoirs. The efficiency of the linguistic analysis scheme was the outcome of a discovery by the founder of Soviet computer linguistics Bel'skaya: in testing the formula designed for machine translation, she came to the conclusion that the success of the experiment was not accidental but predictable. The reason was that the scheme designed on the basis of specialised mathematical texts contained all aspects which should be present in a linguistic analysis of any text.

Soon after the first English-Russian translation, there was another experimental translation of a scientific text from French into Russian. This was carried out by a team directed by O. S. Kulagina at the V. A. Steklov Institute of Mathematics on the *Strela* computer.

1956 saw the foundation of the Association for MT which published 7 issues of its newsletter. In 1959 it was transformed into the journal *MT and Applied Linguistics.* In 1956 the laboratory of MT was established. The team was directed by Y. A. Motorin, mathematician, linguist and translator.[1] Two years later Y. F. Kalinina joined the team. She brought in her knowledge and experience in linguistics and of Russian as well as practical suggestions for designing the Russian part of the machine dictionary. Her idea was to compose a machine dictionary on the basis of word stems. Therefore Y. F. Kalinina identified ten types of word formation for all grammatical groups. She also determined 77 lexical groups of Russian words and composed a dictionary of collocations, semantic tables, etc. By the middle of 1957 Motorin's team had machine processed a large corpus of social-political articles, comprising almost 5 million words. Frequency dictionaries were made. Out of these the team selected 22,000 English and 40,000 Russian words and expressions which were entered into the machine dictionary. The principle of word selection was based on a frequency rate of at least two occurrences in the text corpus. According to linguistic statistics such dictionaries will cover 98,5 per cent of any English newspaper text, which meant that a computer would translate almost 99 words out of one hundred.

The frequency dictionaries were arranged according to the length of the words (one-syllable, two-syllable, etc. words), and, within groups with the same number of syllables, the entries were arranged alphabetically. There was also a homograph dictionary (with 3,200 entries); a frequency dictionary in which the entries were listed according to their endings; an alphabetically arranged dictionary of collocations (comprising nouns, verbs, adjectives, adverbs, prepositions, conjunctions, and articles) with preceding and following words; a dictionary of phraseological units; tables of English irregular verbs; paradigmatic tables of auxiliary verbs; a mini-concordance correcting spelling mistakes at the entry and exit stages; a programme of polysemantic words; a scheme of syntacti-

cal analysis, etc. There was, furthermore, a dictionary containing all punctuation marks which were regarded as words.

In 1959 Motorin's team made a test which showed that their programme could translate any social-political article from English papers as well as certain scientific and technical texts into Russian. A machine-translated text was edited as and given the layout of a normal page. Although some aspects of it still needed to be improved, the MT algorithm was compatible with any type of computer. It made the task of building specialised translation machines viable.

This algorithm of MT was the first economically efficient one. The success of the team's work was due, on the one hand, to the integrity and collective commitment of the research team to the objective of designing a working algorithm for translation from English into Russian and, on the other hand, by substantial resources and technical means with which the laboratory was provided.

In the summer of 1958 the First Union Conference on MT which comprised scientists from Moscow, Leningrad, Kiev, Yerevan, and other cities was held in Moscow. In her conference paper, I. K. Bel'skaya challenged the view by many scholars who thought the possibilities of formalizing language limited. She made the provocative statement that not only phonetic, lexical and grammatical aspects of language could be formalized but even its semantic aspects. However, the precondition for complete formalization, she stressed, was "a many-faceted analysis of real written and oral discourse, a detailed study of real situations in current English ... with a vast corpus of books and articles on science and technology together with pieces of fiction which yield information about specific aspects in a more explicit and distinct shape". "I would not even exclude the possibility", she remarked, "of using books with folklore idioms which may occasionally also be fruitful for analysis". Bel'skaya claimed that a linguistic analysis based on the structure of real language, and principles observed in operation, but not abstract theorising, was crucial for machine translation.

The possibility of linguistic formalization of texts and the adjustability of a scheme to linguistic analysis of any piece of writing, including fiction, was put forward in Bel'skaya's paper at a UNESCO Conference in 1959. In order to prove her point, she re-

ferred to several experimental samples of MT from works by Charles Dickens, John Galsworthy, and Edgar Allan Poe. Bel'skaya's further research (till her sudden death in 1964) focussed on finding ways of making the formula of linguistic analysis more flexible and suitable for such a dynamic object as language. She stressed that from the very start, the machine scheme should be made as adaptable and self-regulating as possible for it to improve. The symbols used in the design of formulas should be simple and clear. The qualities of flexibility, openness to perfection and simplicity are the key merits of Bel'skaya's formula for automatic linguistic analysis.

Machine Translation research was carried out in many countries, e.g. USA, Britain, Mexico, and Japan. However, the Soviet Union was as that time unanimously acknowledged as leading in the design of MT systems. Within the USSR research in MT was carried out in a number of scientific institutions and educational establishments in, for instance Leningrad, Novosibirsk, and Tashkent. In Moscow the problems were studied at the Institute of Scientific and Technical Information of the USSR, at the Central Research Institute of Patent Information, at the V.A.Steklov Institute of Mathematics, by numerous Soviet scholars.[2]

Among the ideas suggested by linguists was that of metalanguage. A metalanguage or carrier language is a system of symbols that offers an explicit and convenient way of presenting the contents of a text for Machine Translation. Linguists suggested English, Esperanto or another artificial language as metalanguage. N. D. Andreyev, Head of the MT Laboratory at the Leningrad University, came forward with a most interesting suggestion. He suggested that a metalanguage be constructed on the basis of grammar and vocabulary of different languages by the incorporation of the grammar rules and lexical units which were shared by most languages and that they be formalized in machine-compatible symbols. However, systems operating with metalanguages did not lead to tangible results. Nevertheless the idea of a metalanguage still exists: R. Briggs, an American specialist in artificial intelligence, has suggested that Sanskrit be used as a metalanguage.

It should be noted that in the 1950s and especially 1960s many linguists were involved in fruitless theorising about the design of a so-called "software algorithm of the future" which, however, could

never have been computerised. There were other practical problems for many research groups engaged in Machine Translation, such as isolation, absence of professional networks, as well as poor technical equipment and inadequate financial support. Also, the ministerial and departmental officials in Russia were not interested in the practical results of MT and its implementation. They thought the volume of scientific and technical information from abroad could well be processed by human translators. The researchers' enthusiasm also quickly faded because of the absence of immediate rewarding results. An article by Yehosua Bar-Hillel, *'The Future of Machine Translation'* (Bar-Hillel: 1962), which was translated into Russian and published almost simultaneously in the Moscow journals *Voprosi Yazikoznaniya* and *Filologicheskiye Nauki* in 1962, also had a negative influence on the scholarly opinion in the Soviet Union. Bar-Hillel strongly doubted that MT strategies would be successful in the next 20 or 30 years. These developments added to the disappointment with MT research and practical work which came to be felt in the early 60s. Few enthusiasts remained. Few teams stayed afloat while most others either dissolved quickly or were officially closed. This is true of the departments of applied linguistics in a number of leading educational establishments in the USSR.

I shall not pursue this any further. I shall only emphasize that in spite of a certain recession in the field of MT in the 1960s and 1970s and a sceptical attitude to it both in the USSR and elsewhere, MT went on developing in the USA, Japan, in the former Soviet Union and some other countries.[3]

In the last decade, interest in theoretical and practical research in MT has grown rapidly. It is due to a number of reasons. First, to the set-up of effective commercial systems of MT and MAT in Europe and Japan. Secondly, to the growing demand of the offices and industrial enterprises for timely and well-qualified translation service. Thirdly, to international cooperation in Machine Translation. And finally, to the practice of using PCs for solving translation-related tasks.

Funding of projects aimed at making translation automatic has substantially increased. The number of individual and team researchers in the field of machine linguists has increased considerably.

For the second time in its 50-year-old history MT is enjoying a boost - and this time it is with us for keeps.

Notes

1. The team consisted of V. A. Pavlov, E. V. Yevreinov, Y. N. Marchuk, D.A. Zhukov, Y. Nikolayev, A. Bogomolkin, Y. Knyaginin, and V.I. Tschebinin.
2. O. S. Kulagina, Y. V. Paducheva, T. M. Nikolayeva (Bel'skaya's collaborator), N. D. Andreyev and others.
3. MT research came to be located in several universities and specialised centres like Grenoble (France), Saarbrucken (Germany), Montreal (Canada), Texas (USA), Kyoto (Japan), Eurotra Project (European Union), Moscow, Leningrad (former USSR).

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