Machine Translation as a complex system, and the phenomenon of Esperanto

Gobbo, F.

Published in:
Interdisciplinary Description of Complex Systems

DOI:
10.7906/indecs.13.2.6

Interdisciplinary Description of Complex Systems 13(2), 264-274, 2015

MACHINE TRANSLATION AS A COMPLEX SYSTEM, AND THE PHENOMENON OF ESPERANTO

Federico Gobbo*

Chair of Interlinguistics and Esperanto, University of Amsterdam
Amsterdam, Netherlands

University of Torino
Torino, Italy

University of Milano-Bicocca
Milano, Italy

DOI: 10.7906/indecs.13.2.6
Regular article

Received: 1 June 2014.
Accepted: 1 July 2014.

ABSTRACT

The history of machine translation and the history of Esperanto have long been connected, as they are two different ways to deal with the same problem: the problem of communication across language barriers. Language can be considered a Complex Adaptive System (CAS), and machine translation too. In fact, there are multiple agents (both natural and artificial) involved, interacting with one another and committed to achieve a common goal, i.e., the machine translation task. The main characteristics of language as a CAS are also shared in machine translation, especially if we consider the example-based, statistical approach, which is nowadays paradigmatic and unavoidable. In fact, control is distributed, there is no ideal representing agent (intrinsic diversity), there are perpetual dynamics in performance, adapted through amplification and competition of new examples from the crowd of users. On the other hand, Esperanto, being a living language, can be considered a CAS, but of a special kind, because its intrinsic regularity in structure simplifies the task of machine translation, at least up to a certain level. This paper reviews how Esperanto has enhanced the development of human-machine communication in general and within machine translation in particular, tracing some prospects for further development of machine translation, where Esperanto could play a key role.

KEY WORDS

machine translation, complex adaptive systems, Esperanto, structural regularity

CLASSIFICATION

JEL: O35

PACS: 89.75.Fb

*Corresponding author, η: F.Gobbo@uva.nl; +31 20 525 4884;
Universiteit van Amsterdam, Spuistraat 210, kmr 342, 1012 VT Amsterdam, Netherlands

INTRODUCTION

The myth of the Tower of Babel is rooted in the foundational construction of the very idea of Europe, as shown for instance by Eco [1] and Steiner [2]. In the most common interpretation of this myth, multilingualism is a curse inflicted by God on humankind because of its hubris, namely its proud willingness to employ its intelligence. One of the most evident manifestations of the use of human intelligence is technology; and the Tower of Babel – the highest tower built on earth and with the aim of being as powerful as God – has become its symbol. Traditionally, there are three different linguistic responses to the myth of Babel: first, the quest for the primitive, perfect language of the ancient pre-Babel times, from which all others descend, i.e., the *Ur-Sprache*; second, the planning of an international auxiliary language on a rational or logical basis – however this is defined – so as to be easily grasped and utilised for practical purposes, from scientific communication to commerce; third, the improvement of the technical means for translation. The first response led scholars to compare ancient languages and hence to form the basis of historical linguistics with the emergence of proto-Indo-European studies. One of the most interesting results of the second response was the Esperanto phenomenon, while machine translation was the third response – an answer developed in contemporary times. In short, Esperanto and machine translation can be considered different and parallel responses to the same question at the same time, with some interesting intersections. In this paper, I will analyse them from the perspective of Complex Adaptive Systems (CAS). First, I will ask why it makes sense to consider natural languages and the activity of translation in such a framework. Then, I will instantiate the two case studies – Esperanto and machine translation – from the perspective of CAS. Finally, I will add some reflections on their intersections, along with some considerations that apply to both.

NATURAL LANGUAGE AND THE ACT OF TRANSLATION AS A COMPLEX ADAPTIVE SYSTEM

In a position paper by Beckner et al. [3] the five authors argue that natural languages are appropriately understood as CAS, given that their key feature is adaptivity. For the past several decades, complex systems have been regarded as a way of modelling non-trivial phenomena, reinforced by specific mathematical theories appropriate to the area of application (for recent advances in the life sciences, see [4]). In particular, they have proved to be useful in situations where the human factor is crucial, such as in economic simulations, life sciences or psychology. It is surprising that only in recent years has the notion of complex systems been applied to natural languages. In this regard, the volume edited by Ellis and Larsen-Freeman [5] on language as a complex adaptive system fills an important gap in the literature. We should note that the contributors to this volume take a *socio*linguistic approach to natural languages, following the tradition of cognitive linguistics. In particular, they address languages that are alive, sustained by a network of agents (in systemic terms) that form a speech community where each agent is a speaker (in linguistic terms). That said, it soon becomes evident that natural languages are indeed adaptive systems, in which previous behaviour influences current and future behaviour. Proof is offered by the fact that no living language is static. In other words, every living language is subject to change, and is therefore an *adaptive* system.

The behaviour of agents of a linguistic system can be described as a collection of utterances, i.e., regular production of signals in a given medium of the given language [6]. This collection is produced either in spoken or written form – or signed, in the special case of sign languages. The production of utterances, where usage-based patterns can be identified, is the main level of analysis. Within these patterns, grammatical constructions can be identified,

forming the locutionary face, as well as intention (the illocutionary face) and the taking up – or not – of intention in the real world (the perlocutionary face; see [6, 7]). However, these three faces are not enough to give a full account of a given language. In fact, speakers feed languages through utterances in various ways, also according to variables peripheral or external to the system, such as social prestige or physical circumstances. This variety of elements is the source of complexity in the adaptive system under investigation (for more details, see [3]). Accordingly, a human language is not only an adaptive system but also a complex one – in short, a CAS.

The act of translation adds a meta-level of complexity to the levels just explained. First, at least two different languages are needed for a translation to happen; this is a truism, but it illuminates the fact that two autonomous CAS's, the source and the target languages, are involved in the process of translation. But their intertwinement is not straightforward. On a locutionary level, translators are faced with a production of utterances belonging to the source language. In particular, they have to identify the grammatical constructions involved so as to find the usage-based corresponding patterns in the target language. Sometimes, this correspondence does not exist in the target language; in such cases, the translator must simply invent corresponding patterns: a well-known example in Italian is the compound *grattacielo* for the English 'skyscraper'. The act of identification is the perlocutionary face of the system, governed by the intention (the illocutionary level) of the translation, which guides translation choices. Intentions are limited by external factors: the genre of the text is part of its purpose, i.e., the instantiation of the intention of the original writer in the text itself. For example, the translation of a legal document for the United Nations is different from the translation of a newspaper article, which is again very different from the translation of a poem. In the first case, the choice of grammatical constructions will be strict, allowing the translator to choose mostly from a formulaic, highly conventional language. In the second case, that of the newspaper article, a higher degree of freedom will be available. Finally, in the third case, the translation of a poem would have to consider aesthetic factors, such as rhythm and rhyme – factors less pertinent to the other cases. Therefore, the ideal translator would be a full inhabitant of both speech communities, a perfect bilingual speaker, whose utterances could easily switch from one language to the other. Of course, such a translator exists only in some Platonic world of ideas.

ESPERANTO, A FULLY HUMAN LANGUAGE, COMPLEX AND ADAPTIVE

Is Esperanto a linguistic CAS? If so, does it present special features, if set next to natural languages? In order to answer to these questions, we must proceed backwards, checking all the properties of a linguistic CAS one by one in this special case. We will follow the order of those features as presented by Beckner et al. [3].

Distributed Control and Collective Emergence. A living language exists at least at two levels: the agent-speaker and the network of agents, i.e., the speech community. In linguistic terms, an idiolect (the language variety belonging to a single speaker) is controlled by the agents distributed in the network through their interactions, where there is no global coordination among individuals. We can rightly ask if Esperanto, being a planned language, is controlled by a single entity: it is well-known that the language was launched by Ludwik Lejzer Zamenhof in 1887 through the publication of a book, containing a basic grammar, the essential dictionary and some texts. Indeed, the influence of the works and ideas of Zamenhof, especially in the early period of the Esperanto life, was very strong [8]. However, one of the reasons why the language successfully survived the death of its initiator was exactly his far-sighted language policy and attitude: he was perfectly aware that his creation did not belong to him anymore. At the moment of publication in 1887, it became the

possession of any human being who wanted to use it: it was not under copyright, but in the public domain. To become alive and stay alive, Esperanto needed no central authority to coordinate globally its agents' behaviours. This does not imply that special groups of agents cannot influence the behaviour of others in a language considered as a CAS; this is the role of language academies, for example, modelled historically on the example of the Italian *Accademia della Crusca*. Esperanto also has its own language academy *La Akademio de Esperanto*, with similar functions. However, Esperanto can today be considered as defined by the emergence of the utterances of its speakers, collectively considered. This distributed control is evident, as agents-speakers are spread across the world and gather together for conferences, congresses and other fora, nurturing and fostering the language itself.

Intrinsic Diversity. The perfect monolingual speaker of a given language is an *Idealtypus*, an ideal type – in other words, a purely fictional character used to represent a uniform variety of the language under analysis. In cognitive linguistics, where the emphasis is put on concrete language use by real speakers, this convention is never used. In reality, each agent of a language as a CAS is different from the others, as shown by numerous sociolinguistic studies. This is particularly evident in the case of Esperanto, where no monolingual speaker exists; in other words, every Esperanto speaker is at least bilingual, and his or her linguistic repertoire influences the use of Esperanto as well, since he/she is in most cases an L2. Also, there are no significant structural differences that set native speakers apart: Esperanto as an L1 does not constitute a distinctive variety [9].

Perpetual Dynamics. In the literature of Esperanto studies, we still lack a serious scholarly study of the diachrony of Esperanto. However, every Esperanto language expert facing a text written by Zamenhof or the pioneers quickly finds some forms that are no longer in use by the contemporary community. One of the most evident examples is in the construction referring to the language itself: the pioneers wrote of a *lingvo internacia*, modelled on the French *langue internationale*, while in contemporary Esperanto people tend to talk about an *internacia lingvo,* the word order reflecting the English construction 'international language'. There is no doubt that the CAS of Esperanto is perpetually dynamic.

Adaptation through Amplification and Competition of Factors. Adaptation is the result of a complex dynamic of factors sometimes in direct competition with one another. In the case of languages as CAS's, a particularly evident field is the competition between different constructions introduced for the modernisation of the corpus. For example, in the Italian language, the English word 'computer' – intended with the modern meaning of computing machinery, i.e. non-animated agent who computes – was adapted as *elaboratore elettronico* and *calcolatore elettronico* when the first computers were built in Italy in the 1950s. Afterwards the borrowed term *computer* entered Italian usage, and in contemporary Italian it is now the standard form. Analogously, after some years of competition, *komputoro* and *komputero* are now archaisms, while *komputilo* is the default term in Esperanto.

Nonlinearity and Phase Transition. Change in complex systems is often nonlinear: a difference in a small set of parameters can lead to a major change in the overall system. In the case of language development, dramatic changes have been observed in many cases. For example, the transition from Old English to Middle English was the linguistic face of an external major variable, namely the invasion of Britain in the early Middle Ages by different populations, and in particular by the Normans [10]. Another example of phase transition in the case of languages is grammaticalization [11]. In Esperanto, many grammaticalizations are simply inherited from Standard Average European: for example, the use of *piede*, 'foot', in Italian with a PLACE meaning, such as *ai piedi della collina*, 'at the foot of the hill', is also attested in Esperanto and registered in the monolingual dictionary as *ĉe la piedo de la monto*.

Genuine internal grammaticalizations occurring within the complex Esperanto system are relatively few. One such instance is the particle *ekde*, meaning 'since' or 'as of' (*ekde mardo:* as of Tuesday, since Tuesday). This particle is grammaticalized by combining the punctuative *ek-* and the preposition *-de*. According to the online monolingual corpus *tekstaro.com*, it is not recorded in Zamenhof's collected works but is already in use by Eugene A. Lanti, a leading figure of the left-wing Esperanto movement in the 1920s. Today it appears in any textbook for learning the language. The most important phase transitions in Esperanto, from a sociolinguistic point of view, are the two World Wars: however, for ideological reasons, the strong normative and conservative pressure of the speech community did not facilitate nonlinear changes, since emphasis was put on the belief that the Esperanto language should be "easily grasped" by anybody, regardless of that person's linguistic repertoire. On the other hand, Esperanto is not alone among human languages in this regard: many minority languages share the same normative and conservative pressure aimed at preserving the status of the language. In a certain sense, a phase transition is a luxury available only to strong languages.

Sensitivity to and Dependence on Network Structure. The internal structure of complex systems is rarely flat, at least in real-world cases: some connections are stronger than others. Languages are no exception: the study of social networks shows that the strength of the connections between agents-speakers belonging to a given network-community have an effect on the dynamic, putting some constraints on language change and variation. Again, there is still no deep analysis of the social network of the Esperanto community in these terms; nonetheless, personal observations show that some agents in the network act as innovators and others as traditionalists, to the point that most sensitive speakers adapt their linguistic behaviour, particularly their lexical choices, if such agents are present in the interaction.

Change Is Local. In an adaptive system, change never starts globally and uniformly within the system; on the contrary, a given area is subjected to change, and that change spreads across the whole system only later, if at all. Languages are CAS's that reflect the societies to which they belong: in every human society, there are some groups that lead innovation and change, while other parts are more conservative; sometimes innovations succeed in spreading the word (literally!), sometimes not. In the case of Esperanto, a leading role is played by newspapers and journals, and has been since the time of the first one, *La Esperantisto.* That journal was crucial, for example, in spreading the term *Esperantisto,* Esperantist, across the other languages spoken by Esperanto speakers. Nowadays the word appears in the dictionaries of many languages across the world to indicate an Esperanto speaker or an Esperanto enthusiast (sometimes there are enthusiasts who do not actually speak the language, and there are Esperanto speakers who do not embrace the ideology surrounding the language, but that is another question). In recent years, the sociolinguistic situation of Esperanto has become more fluid because of the intensive use of information and communication technologies by Esperantists themselves; the Esperanto Wikipedia is an emerging point of reference for changes, with strong tendencies to innovation.

In sum, Esperanto, as a living language, can be examined like any other living human language in terms of complex adaptive systems.

WHY MACHINE TRANSLATION SHOULD BE REALLY ADAPTIVE

The experience of the Second World War led a group of American scholars and intellectuals to the idea that in the post-war world a priority in the agenda of scientific research should be finding a means of tackling complexity in a manageable way, in particular using 'computing machines', as computers were called at the time, which had proved so useful during the war. For example, Vannevar Bush [12], understanding that information flow would be crucial for

the advancement of knowledge, focussed the attention of his colleagues on hypertexts, which eventually inspired the foundation of the World Wide Web. Warren Weaver, a mathematician, was one of those scholars. In 1948 Weaver published an article in which he recommended that scientists should start to address complex problems in order to contribute more actively to human welfare; what he called 'organized complexity' corresponds to the notion of complex systems presented above. For Weaver, one of the evident examples of organized complexity was the task of translation. Hutchins [13] reports that as early as 1947 he wrote a letter to Norbert Wiener about possible ways to mechanize the task of translation. Later, Weaver was asked to write a memorandum [14], where he suggested considering the text in the foreign language to be translated as a code to be deciphered, applying the algorithms so successfully used during the Second World War. Hutchins [13] also posits the influence of Rudolf Carnap, the father of logical positivism, as Weaver considered the written language as "an expression of logical character".

The memorandum was put to concrete use only in the 1990s – in the IBM Laboratory for the project Cantide [15]. At that point, the needed computational power and corpora of linguistic data in digital form were finally available. Following disillusion at the poor performance of the purely rule-based machine translation systems in vogue in the years 1980, the emerging usage-driven paradigms of machine translation, based on examples and statistics, heralded a revival of the field at the turn of the millennium. As argued before, translation adds a new level of complexity, as at least two linguistic complex adaptive systems are involved. In the case of machine translation, the general idea is to capture the linguistic knowledge of the locutory level of the languages involved by means of translation pairs linking constructions across languages. The usage-driven paradigms mimic the behaviour of professional translators by tracking their past behaviour, collected in parallel corpora of construction translation pairs called 'translation memories'. In the most sophisticated models, a morphosyntactic tree of the construction is also provided [16].

The reliability of the machine translation of a usage-based system is based on the size of the translation memories forming the parallel corpora: in principle, the larger the corpora, the better the translation. However, after more than twenty years of consistent practice in this field, it is clear that parallel corpora are crucial but insufficient. In fact, encyclopaedic knowledge of the world, even if at the periphery of the linguistic CAS, becomes central in machine translation. The kinds of errors made by human translators and by translating machines are quite different. One of the best known unsolved problems is that of named-entity recognition and normalization. To give a simple example, the sentence *Green Day don't like Bush* refers to a punk band, Green Day – and therefore this name should not be translated, since *giorno verde* in Italian (for instance) does not make any sense, while Bush is not a *cespuglio* (bush) but rather a former President of the United States. Furthermore, since more than one U.S. president has been called Bush, the time of publication of the sentence is also relevant. The periphery of the language systems, consisting of pragmatic conventions, social rules, leading proper names and shared knowledge, becomes central to the translation task and constitutes the most compelling challenge to machine translation. This difficulty lends reason to the centrality accorded by cognitive linguists to social interaction as a driving force of languages as CAS's. Such interaction is retained and retrieved by usage-based machine translation systems only as a collection of memories. For this reason, the adaptivity feature of machine translation systems often requires human agents: what is difficult for machines is often trivial for humans. Contemporary usage-based machine translation systems achieve adaptivity through a constant relation with the people using them: the result is a new CAS, which should more properly be called computer-assisted translation, rather than purely machine translation.

MACHINE TRANSLATION AND ESPERANTO: SOME INTERSECTIONS

The intersections between machine translation efforts and the history of Esperanto are not many in terms of absolute numbers; nonetheless they are not without interest. From an anecdotal perspective, it is interesting that Norbert Wiener was well aware of Esperanto for family reasons, his father having been a schoolmate of Zamenhof, the initiator of Esperanto, in Warsaw [17]. Moreover, as a young man Rudolf Carnap attended an Esperanto congress, in the year 1922 [18]. Carnap later studied Ido (an offshoot of Esperanto), impressed by the regularity and logic of its word formation. But the intersections go beyond anedoctal evidence. Let us take a look at the most important instances where Esperanto has intersected with machine translation projects, setting aside a few ephemeral experiments that have been proposed over the years.

From a historical point of view, Esperanto is older than machine translation. It was used by a renowned pioneer of *mechanical* translation called Petr Petrovich Trojanskij. This Soviet scholar and engineer published a Soviet patent in 1933, rediscovered only at the end of the past century, thanks to work by Hutchins (e.g. [19]). A prototype was operational in the years 1938-1942. It used the final morphemes of Esperanto to tag grammatical character to the stems of the source language: *-o* for the nominative nouns, *-j* for the plural, *-n* for the accusative, *-as* for the present tense of verbs, *-i* for infinitives and *-a* for adjectives. This part-of-speech tagging, carried out by a human agent, was intended to help the machine with the translation. A post-editing phase was foreseen, when another human agent would take the tags off the target language. Note that Trojanskij considered only European languages that formed the basis of Esperanto, among them Russian, German and French. In other words, Esperanto was used as a *tertium comparationis* between two natural languages, an intuition already present in the works of the father of Esperanto studies, Eugen Wüster [20].

This role as a grammatical geometry of other languages also lies at the heart of the biggest machine translation project involving Esperanto, DLT (Distributed Language Translation), officially launched by Witkam in 1983 [21] with a feasibility document addressed to the European Commission. DLT was conceived as an answer to the Fifth Generation Computers program in Japan [22]. A six-year DLT pilot project was prepared, with a sophisticated use of Esperanto as a pivot language between the translation source and the translation target, through a formalisation of Esperanto grammar, with some minor modifications, based on the concept of valency and dependency introduced by Tesnière [23]. The semantic problem of disambiguation was also tackled, using largely innovative techniques based on analogy [24]. These techniques acknowledged the need to consider linguistic forms in use a few years prior to the usage-based paradigms, based on statistics and translation memories. Such techniques became the new mantra of machine translation at the turn of the millennium.

At that time, a major change in perspective also occurred regarding Esperanto's role in machine translation. In the most recent systems, Esperanto no longer plays the special role of formalised pivotal language, but functions at the same level as other languages. The most widely used machine translation engine project today is undoubtedly Google Translate. On February 22, 2012, the Google team's official blog announced that Esperanto had been added as one of the Google Translate languages. It quickly performed as well as languages with analogous but much larger corpora: quality results were similar to strong languages such as German and Spanish, with corpora one hundred times the size of those for Esperanto. The development team was impressed: "Esperanto was constructed such that it is easy to learn for humans, and this seems to help automatic translation as well" [25].

Another important machine translation system using Esperanto is Apertium, a free and open source project run by a skilled team of developers and contributors, beginning in 2005 [26].

The starting point of Apertium is that the size of the parallel corpora cannot provide high-quality translations *per se*, while on the contrary a good combination of mild morphosyntactic analysis and transfer rules, rewritten for each language pair, controlled by a team of human collaborators, would be far more efficient. It is important to note that Apertium started in Spain, with Iberian Romance languages in mind, which are genetically and structurally similar. The system proved robust enough to allow for Basque and other non-Iberian languages to be added. The grammatical analysis is in principle not so very dissimilar from Trojanskij's, but contains explicit morphological information as well as explicit rules about word order. Language pairs are often taken from existing translation memories available in the web, but they are always reviewed by the community surrounding the project, to maintain a high standard of quality. There is no pivot language or other metalinguistic level of analysis.

To assess the quality achieved by state-of-the-art machine translation systems and Esperanto, let us take the opening of a newspaper article from *Le Monde Diplomatique*, which has an official Esperanto edition (Table 1). A human translation is compared with machine translations by Google Translate and by Apertium (test carried out on May 28, 2014). The title of the English translation of the article, by Serge Halimi, is *Europe's Brutal Discipline* (the French original apparently is not available on the web). The machine translations in the target language Esperanto were derived from the English human text.

In Table 1, italic bold are the English words that were left untouched because the machine translation system could not solve them, while certain word clusters were underlined to emphasise some interesting phenomena. Interestingly, Google Translate did not solve the very common word *gets*, while on the other hand Apertium was fooled by the British spelling *specialising* (if changed to the American spelling *specializing*, it translates that word as *specialiganta*). This small example shows that statistical systems like Google Translate can easily overcome spelling differences, while on the other hand they can fail to solve *gets tougher* as a single construction because it is not very frequent in the parallel corpus. Meanwhile, Apertium translates the phrase as *akiras pli fortan* (lit. "achieves more strong") which does not make much sense. The sensibility of the human translator completely changes the construction of the entire phrase, and that construction is rendered with *akriĝo* (lit. "getting sharper"); the same is true with *federan ĥimeron* (lit. "federal chimera") for *federal fantasy*, while both machine translations stick with a direct translation, *fantazio*.

An important point of difference between the two machine translation paradigms is the treatment of grammaticality: statistical systems like Google Translate do not consider grammaticality very important, focussing on the idea that the reader is interested in meaning, not in grammaticality; while rule-based systems like Apertium consider ungrammaticality a serious weakness for comprehension. This difference is reflected in the internal structure of the two complex systems: Google Translate has a team of developers internal to Google with no direct connection to the users who propose corrections, whereas all agents who can modify Apertium at any level are in contact with a mailing list, wiki and other meeting places, so that the result is much more collective. Apertium seems to be more adaptive, as the human agents and the non-human ones are interconnected better than in Google Translate, where the rigid distinction between in-group (Google developers) and out-group (agents as users) does not permit a real collaboration to improve the system itself.

Readers familiar with Esperanto grammar will quickly note that Google Translate fails in noun-adjective agreement in number and case, while Apertium respects it far more. In truth, this distinction is not only a matter of grammaticality, but also of meaning and sense. In fact the Google translation of *there is a growing sense* is rendered with the almost opposite meaning: *ne estas kreskanta senco* means literally "there is no growing sense". Apertium also

Table 1. The quality of Esperanto translation of Google translate and Apertium.

English human text	Esperanto human text	Esperanto Google text	Esperanto Apertium text
Europe's brutal discipline. The European utopia is turning into a system for delivering punishment. As Europe's regime gets tougher, there is a growing sense that interchangeable elites are taking advantage of each crisis to tighten their austerity policies and impose their federal fantasy. This twin objective has the support of boardrooms and newsrooms. But even if you boost their ranks with German rentiers, a few Luxembourgers specialising in tax evasion and most of France's Socialist leaders, popular backing for the present "European project" isn't much greater.	La punmaŝino. La eŭropa utopio transformiĝas en punmaŝinon. Sampaŝe kun ties akriĝo instaliĝas sento ke interŝanĝeblaj elitoj profitas el ĉiu krizo por akrigi siajn politikojn de malabundo kaj por trudi sian federan ĥimeron. Tia celo vekas la aliĝon de la kontrolkonsilioj kaj de la redaktejoj. Sed, eĉ se oni aldonas la malmultajn germanajn rentulojn, kelkajn luksemburgajn nompruntantojn kaj la plej multajn francajn socialistojn, oni ne eksterordinare grandigas la popolan bazon de la nuna "eŭropa projekto".	Eŭropo brutala disciplino. La Eŭropa utopio estas igante sistemon por transdoni puno. Kiel eŭropa reĝimo ***gets*** pli malfacila, ne estas kreskanta senco ke interŝanĝeblaj elitoj estas utiligante ĉiun krizo streĉi siajn rigoreco politikoj kaj trudi siajn federacia fantazio. Ĉi ĝemelaj objektivo havas la subtenon de ***boardrooms*** kaj novaĵĉambroj. Sed eĉ se vi pelos iliajn rangojn kun germanaj ***rentiers***, kelkaj ***Luxembourgers*** specialiĝas en impostevito kaj plejparto de la franca Socialista gvidantoj, populara subteno por la aktuala "eŭropa projekto" ne estas multe pli granda.	brutala disciplino de Eŭropo. La eŭropa utopio estas turnanta en sistemo por liveranta punon. Kiel reĝimo de Eŭropo akiras pli fortan, estas kreskanta senton ke interŝanĝeblaj elitoj estas utiliganta ĉiun krizon striktigi iliajn ŝparemecajn politikojn kaj trudi ilian federalan fantazion. Ĉi tiu ĝemela objektivo havas la subtenon de estrarejoj kaj redakciejoj. Sed eĉ se vi akcelas iliajn rangojn kun German ****rentiers***, kelkaj ****Luxembourgers*** ****specialising*** en imposta evito kaj plejparto de Francio-a Socialismaj gvidantoj, populara subteno por la nuna "eŭropa projekto" ne estas tre pli granda.

has some problems in disambiguation, as the Esperanto word *sento*, used in the same point, means "feeling, sensation".

CONCLUDING REMARKS

It would seem that in principle a combination of the two approaches to machine translation could avoid the most common errors in both; on the other hand, a mixed system increases the complexity of the system itself, with the risk, in the worst case, of augmenting both kinds of errors. In any event, it seems that in both approaches Esperanto can function as a source or target language with a considerable degree of regularity compared to other languages, even though no pivot language or explicit metalevel is utilized in either system. Perhaps this is a natural development for Esperanto – namely that it will function as a language like any others, and with good results: the more Esperanto is used, the stronger the result. Esperanto improves its own level of adaptivity when used in machine translation tasks, and at the same times its complexity grows.

ACKNOWLEDGMENTS

The author occupies the Special Chair in Interlinguistics and Esperanto at the University of Amsterdam (UvA), Faculty of Humanities, on behalf of the Universal Esperanto Association (UEA, Rotterdam, The Netherlands). The research leading to the present paper has received funding from the European Community's Seventh Framework Programme under grant agreement No. 613344 (Project MIME). The content and opinions expressed in this article are those of the author and do not necessarily reflect the opinions of the institutions supporting him.

REFERENCES

[1] Eco, U.: *La ricerca della lingua perfetta nella cultura europea*.
Laterza, Bari, 1993,

[2] Steiner, G.: *After Babel: Aspects of Language and Translation*. 3rd edition.
Oxford University Press, Oxford, 1998,

[3] Beckner, C. et al.: *Language is a complex adaptive system: Position paper*.
Language Learning **59**(S1), 1-26, 2009,

[4] Bellomo, N. and Brezzi, F.: *Complex systems: New challenges with modeling headaches*.
Mathematical Models and Methods in Applied Sciences **24**(2), 213-219, 2014,
http://dx.doi.org/10.1142/S0218202513020016,

[5] Ellis, N.C. and Larsen-Freeman, D., eds.: *Language as a Complex Adaptive System*.
John Wiley & Sons, Chichester, 2009,

[6] Austin, J.L.: *How To Do Things with Words*.
Harvard University Press, Cambridge, Mass., 1962,

[7] Searle, J.: *Speech Acts: An Essay in the Philosophy of Language*.
Cambridge University Press, Cambridge, 1969,
http://dx.doi.org/10.1017/CBO9781139173438,

[8] Korzhenkov, A.; Tonkin, H. and Richmond, I.M.: *Zamenhof: The Life, Works and Ideas of the Author of Esperanto*.
Mondial, New York, 2010,

[9] Lindstedt, J.: *Native Esperanto as a test case for natural language*.
SKY Journal of Linguistics **19**(S1), 47-55, 2006,

[10] Mallory, J.P.: *In Search of the Indo-Europeans: Language, Archaeology and Myth*.
Thames & Hudson, London, 1989,

[11] Giacalone Ramat, A. and Hopper, P.J., eds.: *The Limits of Grammaticalization*.
John Benjamins, Amsterdam, 1998,
http://dx.doi.org/10.1075/tsl.37,

[12] Bush, V.: *As we may think*.
The Atlantic. July 1945,

[13] Hutchins, J.: *Warren Weaver Memorandum: 50th anniversary of machine translation*.
MT News International **8**(No. 1, Issue 22), 5-6 & 15, 1999,

[14] Weaver, W.: *Translation*.
Reprinted 1955 in: Locke, W.N. and Booth, A.D., eds.: *Machine Translation of Languages: Fourteen Essays*. MIT Press, Cambridge, Mass., pp.15-23, 1949,

[15] Brown, P.F. et al.: *A statistical approach to machine translation*.
Computational Linguistics **16**(2), 79-85, 1990,

[16] Koehn, P.: *Statistical Machine Translation*.
Cambridge University Press, Cambridge, 2009,
http://dx.doi.org/10.1017/CBO9780511815829,

[17] Gobbo, F. and Durnová, H.: *From universal to programming languages*.
Informal Proceedings of Computability in Europe 2014. Budapest. To be published.

[18] Schilpp, P.A., ed.: *The Philosophy of Rudolf Carnap*.
Open Court, New York, 1963,

[19] Hutchins, J.: *The first MT patents*.
MT News International (Issue 5), 14-16, 1993,
[20] Gobbo, F.: *L'esperanto e la traduzione automatica*.
In: Borbone, P.G.; Mengozzi, A. and Tosco, M., eds.: *Loquentes Linguis. Linguistic and Oriental Studies in Honour of Fabrizio A. Pennacchietti*. Harassowitz, Wiesbaden, pp.319-327, 2006,
[21] Witkam, T.: *Distributed Language Translation. Feasibility Study of a Multilingual Facility for Videotex Information Networks*.
Internal document, BSO, Utrecht, 1983,
[22] Witkam, T.: *History and Heritage of the DLT (Distributed Language Translation) Project*.
Private publication, 2006,
[23] Schubert, K.: *Metataxis: Contrastive Dependency Syntax for Machine Translation*.
Foris, Dordrecht, 1987,
[24] Sadler, V.: *Working with Analogical Semantics: Disambiguation Techniques in DLT*.
Foris, Dordrecht, 1989,
[25] Brants, T.: *Tutmonda helplingvo por ĉiuj homoj*.
The Official Google translate blog. 22 February, 2012,
[26] Forcada, M.L. et al.: *Apertium: a free/open-source platform for rule-based machine translation*.
Machine Translation **25**(2) 127-144, 2011.
http://dx.doi.org/10.1007/s10590-011-9090-0.