A Rule Based Machine Translation Scheme from Greek to Greek Sign Language: Production of Different Types of Large Corpora

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Abstract: - One of the aims of Assistive Technologies is to help people with disabilities to communicate with others and to provide means of access to information. As an aid to Deaf people, in this work we present a novel prototype Rule Based Machine Translation (RBMT) system for the creation of large quality written Greek Sign Language (GSL) glossed corpora. In particular, the proposed RBMT system supports the professional translator of GSL to produce different kinds of GSL glossed corpus. Evaluation of the proposed scheme is carried out for the weather reports domain, were 20,284 tokens and 1,000 sentences have been produced. By using the BiLingual Evaluation Understudy (BLEU) metric score [32], our prototyped RBMT system achieves a relative score of 84% for 4-gram evaluation and 90% for 1-gram.

Key-Words: - machine translation, Greek, Greek Sign Language, GSL, Deaf people communication, SiGML, 3D Avatar.

1 Introduction

Translation helps people to communicate across linguistic and cultural barriers. However, according to Isabelle and Foster [24], translation is too expensive, and its cost is unlikely to fall substantially enough, to constitute it as a practical solution to the everyday needs of ordinary people. Machine translation can help break linguistic barriers and make translation affordable to many people. This situation is especially important for Deaf people, since translation supports the communication between Deaf and hearing communities and provides Deaf people with the same opportunities to access information as everyone else [33].

1.1. Sign Languages – The Greek Sign Language

Sign languages (SLs) exploit a different physical medium from the oral-aural system of spoken languages. SLs are gestural-visual languages, and this difference in modality causes SLs to constitute another branch within the typology of languages. However, there are still many myths around SLs. One of the most common and enduring myths is that the SL is universal; however, in reality, each country generally has its own, native sign language [5][17].

This paper focuses on the Greek Sign Language (GSL), which is a complete language using the same grammar mechanisms incorporated by the oral language[1]. According to the Greek law no. 2817/2000[2], GSL is the official language of the Greek Deaf community[3], while in 2013 the Greek Deaf Federation has published a formal announcement demanding the institutional recognition of GSL[4]. Currently more than 40,000[5] people use GSL. Additionally, another common myth is that there is a correlation between the Greek spoken language and GSL. However SLs do not derive from spoken languages, but, as natural languages, they are influenced by their contact to other languages, allowing the development of dialects and varieties [40].

1.2. Problems of SLs

According to Porta et. al. [33] regarding the fundamental problems of SLs, most contemporary works on SLs have adopted language theories created for the spoken language instead of developing new theories. From the point of view of natural language processing, SLs are still under-resourced or low-density languages – that is to say, little or no specific technology is available for these languages, and computerized linguistic resources, such as corpora or lexicons, are very scarce.

Additionally, another major problem of SLs is the lack of a writing system. Strictly speaking, the only way to represent SLs is by using video and this is why there is lack of large corpora. The limitations in composing, editing and reusing SL utterances as well as their consequences for Deaf education and communication have been systematically mentioned in the SL studies literature since the second half of the twentieth century [11]. However, several notational systems exist. The most important include Stokoe [41], SignWriting [43], HamNoSys [34] and Neidle [31]. SignWriting was conceived primarily as a writing system, and has its roots in DanceWriting [42], a notation for reading and writing dance movements. HamNoSys was conceived as a phonological transcription system for SLs, with the same objective as the International Phonetic Alphabet (IPA) for spoken languages. A very promising system is SiGML [14], which represents the 3-D properties of SLs. Last but not least, the "si5s" writing system [2] has been proposed for the American Sign Language (ASL).

Furthermore, regarding GSL and to the best of the authors' knowledge, currently no Language Model exists. To confront the aforementioned problems, in this paper an innovative RBMT system is proposed, which quickly produces high quality large glossed GSL corpus. In particular, the focus is primarily on syntax, so glosses are used instead of phonological notation. Glossing is a commonly used system for explaining or representing the meaning of signs and the grammatical structure of signed phrases and sentences in a text, written in another language. However, glossing is not a writing system that could be understood by SL users. For this reason, a novel gloss system is proposed based on the Berkley system (for the ASL), which is also decorated with Non Manual Component Sign (NmCs) tag features. The proposed scheme also enables the production of a simpler version of gloss without NmCs tags, adopted from the Deaf Community and especially from the bilingual deaf people who use a similar written Greek system in the Social Media.

The proposed scheme also uses a lexical database in SiGML [14]. This database was created with the help of eSIGN [18],[19] editor software which allows the user to compose signed text to be performed by the eSIGN Avatar which is a virtual animated Agent.

To sum up the main innovations of the proposed scheme include:

- The implemented GSL MT System is based on open source Toolkits.
- The overall scheme, with the help of a professional translator, can produce different kinds of large quality GSL Glossed Corpus that can be used for several purposes.
- The performance of the proposed GSL scheme is evaluated by the BLEU metric score [32].
- The novel GSL Glossed system contains POS and NmCs info and it can be straightforwardly used for producing 3D animation using SIGML lexical database or other 2D or 3D animation technology in future.

The rest of this paper is organized as follows: in Section 2 we present a sketch of GSL and presets a review of Rule-based SL MT Systems. In Section 3 the related work is analyzed and we describe how our prototyped RBMT system produces a different kind of GSL glossed corpus. In section 4 we

[1] https://goo.gl/pAemOJ
https://en.wikipedia.org/wiki/Greek_Sign_Language

[2] https://goo.gl/oItdK0

[3] https://goo.gl/GGPIUo

[4] http://www.omke.gr/anakoinwseis/diakirixi-syntagmatiki-anagnwrish-eng/

[5] https://goo.gl/OZPAX5

evaluate the proposed RBMT system. Finally, in section 5 concludes this paper, providing also some directions for future work.

2 Literature Review of SL MT Systems

2.1 Background

Machine Translation (MT) of spoken languages has its roots in the 1940s, with a significant expansion of interest in the late 70s and 80s [45]. A similar level of development cannot be said for SL MT. Widespread research in this area did not emerge until the 1990s, where linguistic analysis of SLs has appeared [30]. Despite this late venture, the development of SL MT systems has roughly followed that of spoken language MT from ‘second generation’ rule-based approaches towards data-driven approaches. The ‘second generation’ or rule-based approaches to MT, emerged in the 1970s/1980s with the development of systems such as Meteo [8] [9] and Systran [44]. These systems are examples of the first commercially adopted MT systems to successfully translate spoken languages.

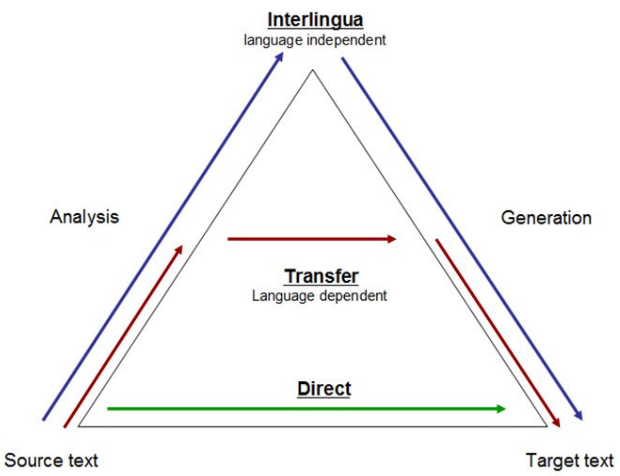

Figure 1: The Vauquois Pyramid

Rule-based approaches may be sub-classified into transfer– and interlingua–based methodologies. The Vauquois Pyramid, shown in Figure 1 [23], is widely used in MT circles to demonstrate the relative effort involved in translation processes. Transfer approaches, being language-dependent, need to know the source and target languages. Interlingua approaches tend to enact a deeper analysis of the source language sentence that creates structures of a more semantic nature. Both methods have their advantages and disadvantages.

2.2. Sketch of GSL

The most important documentation for a language is a reference grammar, which documents the principles governing the construction of words and all kinds of grammatical structures found in a language. Currently and regarding GSL, there are some attempts to gather resources, create a dictionary and annotated corpora and analyze a set of signers’ data deriving from the annotated corpora [12],[10]. Additionally another interesting initiative to develop the blueprint for SL grammars is carried out by the SignGram COST Action[6].

2.3. Rule-based SL MT Systems

All MT systems for SLs published up to 2003 were just works in progress or simple demonstrators [22]. However, some systems were particularly distinguished, including the ZARDOZ system [46], the ViSiCAST Translator [4], the ASL Workbench [38], the SL translation via DRT and HPSG Safar et al. [35] and the TEAM project Zhao et al. [47]. All these systems were rule-based and made use of transfer-based or interlingua-based approaches. The only approach dealing with classifier predicates was that of Huenerfauth [21], who proposed a multi-path approach combining interlingua, transfer and direct approaches as a whole.

For Spanish to Spanish Sign Language (LSE), Baldassarri and Royo-Santas [3] described a rule-based demonstrator. Spanish is analyzed using FreeLing dependency analysis [1]. The dependency analysis through grammatical rules is transformed into a series of glosses. The system was tested with 92 sentences containing a total of 561 words. Appropriate dictionary entries were created for the evaluation, with very satisfactory results: 96% of the words were correctly translated, and 93.7% of them were in correct order. Another interesting Spanish SL MT system is the rule-based Spanish-to-LSE MT system based on Apertium, a free/open-source platform [15]. There are no published results on this system but it is available online[7].

Now regarding GSL, Kouremenos et. al [29], presented a prototype Greek text to GSL conversion system. In that work, the detailed implementation of the language-processing component is provided, focusing upon the inherent problems of knowledge elicitation of sign language (SL) grammar and its implementation within a parser framework.

[6] SignGram COSTS Action IS-1006 ‘‘A blueprint for sign language grammars—unravelling the grammars of European sign languages: pathways to full citizenship of deaf signers and to the protection of their linguistic heritage’’ (www.signgram.eu).

[7] http://aplica.prompsit.com/en/text_es_ssp (accessed July 2016).

Recently Efthimiou et. al. [11] presented the implementation of a post-processing stage to a grammar-based machine translation (MT) system from written Greek to GSL.

2.4. Overall Discussion and Focus of the Proposed Scheme

This paper attempts to solve a very serious problem of the GSL, the lack of large GSL corpora. Towards this direction, a processing methodology is proposed for creating large quality parallel data for SLs by a human professional translator. The translator uses a simple rule-based system based on Python, open source tools which incorporate a transfer module in case of interlingua approaches and a robust grammar tree transfer parser. All aforementioned components (except the open source tools) have been fully developed and extensively tested by the authors.

3 The Proposed RBMT System for Greek-to-GSL Translation

The proposed RBMT system has taken into consideration the Basic Unification Grammar principles [26], [36], [6], [7]. For its overall development, different tools and technologies have been combined: (a) AUEB's POS Parser[8] , (b) the NLTK (Natural Language Toolkit) 3.0 suite[9] , which is a free, open source, community-driven, leading platform for building Python programs to work with human language data, (c) Java and (d) Perl scripts. Additionally, translation is supervised by a professional translator, so that output texts are corrected and new transfer rules and lexicon mapping data are added to the RBMT, so that any newly appearing cases (linguistic phenomena) are covered.

3.1. Overall Architecture

In order to translate Greek to GSL, transfer at the syntactic functions level is carried out, based on constituency partial tree analysis. Figure 3 illustrates the system's architecture, including its connections to other external modules. The constituency tree, which has been created by the analysis module, provides a summary of the source sentence's GSL structure. Then Gloss sequence and Gloss synthesis are performed to complement the structure, so that the final sentence is formed. This sentence is GSL Gloss Text that uses different corpus types.

The transfer module incorporates a bilingual lexicon and specific knowledge from the language pair-specific rule database to transfer the Greek constituency tree structure into the corresponding GSL constituency tree structure. Word ordering and morphological rules are applied to the transferred constituency tree, so that the output of the generation stage is a sequence of written glosses with morphological and non-manual components' indications. The proposed written GSL glosses system uses the code style of BERKLEY Gloss System [20], [37] as a transcribing system, which abstracts away the phonological representation of signs. Also our system also uses a multimedia database lexicon for export output in SiGML code system, that could be synthesized by avatar SiGML technology [14]. Details of the different stages of the MT strategy are provided in the following subsections (Figure 2).

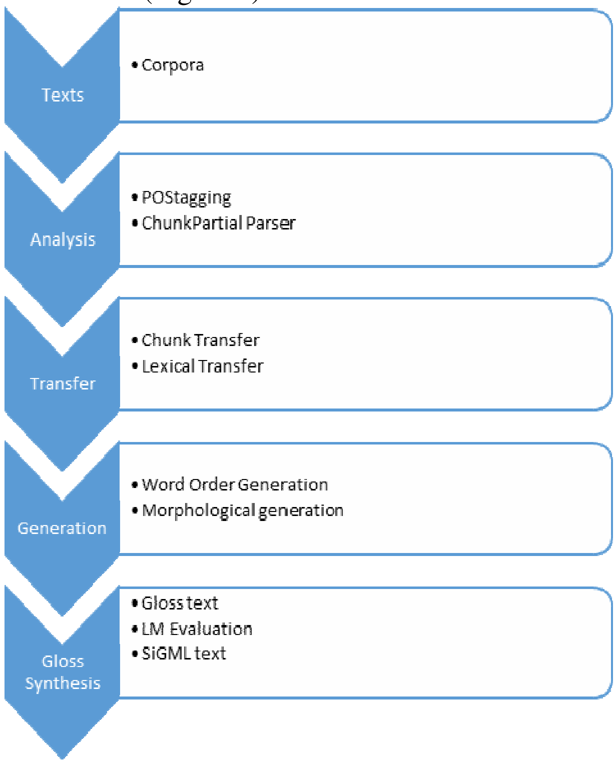

Figure 2: Architecture of the system

```
S
 (NP Βροχές/NoCmFePlAc και/CjCo καταιγίδες/NoCmFePlAc)
 (VB θα/PtFu εκδηλωθούν/VbMnIdXx03PlXxPePvXx)
 (NP
   κατά/AsPpSp
   τόπους/NoCmMaPlAc
   στη/AsPpPaFeSgAc
   Δυτική/AjBaFeSgAc
   Ελλάδα/NoPrFeSgAc)
 (NP-CM Τα/AtDfNePlNm Χριστούγεννα/NoPrNePlAc)
)
```

Figure 3 : POS Parsed and Chunked Sentence

[8] http://nlp.cs.aueb.gr/software.html

[9] http://www.nltk.org/

3.2. System Export

The generation stage (as a previous step before GSL Avatar synthesis), generates the sequence of GSL glosses decorated with non-manual component tags, using code types of the BERKLEY Gloss system [20], [37] (Figure 4).

```
ΧΡΙΣΤΟΥΓΕΝΝΑ/NoAcNePlXx
ΜΕΤΑ/Pt/ΧΛ(ΜΕΤΑ)    ΓΙΝΕΙ/Vb    ΒΡΟΧΗ/NoAcFePlXx
ΚΑΙ/Cj
ΚΑΤΑΙΓΙΔΑ/NoAcFePlXx/ΜΧ(ΕΝΤΑΣΗ)/ΜΓΛ(ΦΟΥΣΚΩΜ
ΕΝΑ)  ANT_3/PreDict/MT(ΑΝΟΙΧΤΑ)  ΤΟΠΟΣ/ΤΠΘ(Χ1)-
ΤΟΠΟΣ/ΤΠΘ(Χ2)/No        ANT_3/PreDict/MT(ΑΝΟΙΧΤΑ)
ΕΛΛΑΔΑ/NoAcFeSgXx ΔΥΤΙΚΟΣ/AjAcFeSgXx ./PTERM_P
```

Figure 4 : Gloss System

The proposed scheme also uses a lexical database in SiGML [14] we created with the help of eSIGN [19] editor software which allows the user to compose signed text to be performed by the eSIGN Avatar which is a virtual animated Agent. In the following Figure 5 you can see an example of the sign "after" ("ΜΕΤΑ").

```
<sigml>

<hns_sign gloss="META">
        <hamnosys_nonmanual>
        <hnm_mouthpicture                picture="META"/>
        </hamnosys_nonmanual>
        <hamnosys_manual>
        <hamflathand/>
        <hamextfingerl/>                      <hampalml/>
                        <hamshoulders/>
        <hammover/>                           <hamarcu/>
                </hamnosys_manual>            </hns_sign>

</sigml>
```

Figure 5 : SiGML format of word "after".

4. Evaluation of the Proposed RBMT System

Human evaluation is fundamental and remains crucial to proper assessment of the quality of MT systems. When the output of an MT system is evaluated, however, the accuracy of translation process is taken into account.

Initially, by performing text mining from several weather-related web pages[10], we have created a large Greek-language corpus, consisting of 1,015 sentences and 20,287 tokens. Next the corpus was divided into 10 sub-corpuses (about 100 sentences per sub-corpus). In parallel an experienced human interpreter was in charge of translating the Greek written corpus into written GSL Glosses, decorated with NmCs tags.

For measuring the translation accuracy of the proposed RBMT system, the Bleu Score [32] for 1 to 4-gram is used. Results are provided in Table 1 as well as in Figure 6.

Sents	RBMT Rules	Bleu Score	Bleu 1 gram	Bleu 2 gram	Bleu 3 gram
10	8	0,0607	0,6795	0,2880	0,1755
20	20	0,5547	0,9086	0,8084	0,7401
30	30	0,7974	0,9454	0,8900	0,8486
100	46	0,8369	0,9453	0,8942	0,8537
200	65	0,8404	0,9413	0,8897	0,8494
300	71	0,8398	0,9399	0,8863	0,8444
400	90	0,8562	0,9393	0,8901	0,8518
500	100	0,8555	0,9401	0,8907	0,8521
600	107	0,8552	0,9399	0,8903	0,8517
800	108	0,8552	0,9399	0,8903	0,8517
900	109	0,8555	0,9399	0,8907	0,8521

Table 1: Bleu Metric Scores Progress Table for the Proposed RBMT System

As it can be observed, improvement in translation is achieved even from the first sentences and rules. In particular, for 10 sentences and 8 rules the BLEU score is 6%. However, for 20 sentences and 20 rules BLEU score reaches 55%, while for 30 sentences and 30 rules it rises to 79%. From this point on, the improvement rises smoothly, since the focus turns to the quality of translation and dictionary mappings so that rarer phenomena are also considered. Here it should also be mentioned that the larger the n-gram the better the quality of translation.

On the other hand, and for comparison reasons, it is worth noting that similar experiments can be found in the literature. Kanis [25] in his work, the training set consisted of 12,616 sentences, regarding Czech to Czech Sign Language. In these experiments the proposed system reached a BLEU score of 0.81, a WER of 13.14% and a PER of 11.64%. Similarly, in [39] and in case of German to German Sign Language two experiments have been performed. In these cases, the BLEU and PER obtained were 0.021 and 85.7% for the first experiment and 0.026 and 81.1% for the second experiment respectively. However, the reported baseline with the open source toolkit for statistical machine translation Moses [27] was 0.181 BLEU and a 71.0% TER with a training set of 2,565 sentences and a test set of 512

[10] http://www.deltiokairou.gr/, http://www.weather.gr/, http://meteo.gr/

sentences. By combining several systems, they finally reached a BLEU of 0.234 and a TER of 65.5%. Here it should be noted that the disparity between these results is because Czech and Czech Sign Language have the same surface order, but German and German Sign Language do not. Furthermore, results confirm that data scarcity and domain sparseness lead the data-based approaches to perform worse than the rule-based systems. Providing bilingual lexical resources has a positive effect in data-based approaches. We think that this result should not be interpreted as domain independence. Instead, we consider that data are not still enough to measure the out-of-domain effect. On the rule-based translation side, the most important conclusion that can be drawn from the above experiments is that the order of signs is similar to the order of words in the Greek fragments. We think that this result should not mean that GSL and Greek have similar word orders or that the order generated by the system is not valid. We consider that GSL order admits some degree of freedom and that the order of signs in the learning corpus is also valid for the purpose of communication. At this point, deeper and more extensive experiments, measuring human understanding, should be performed to draw further conclusions.

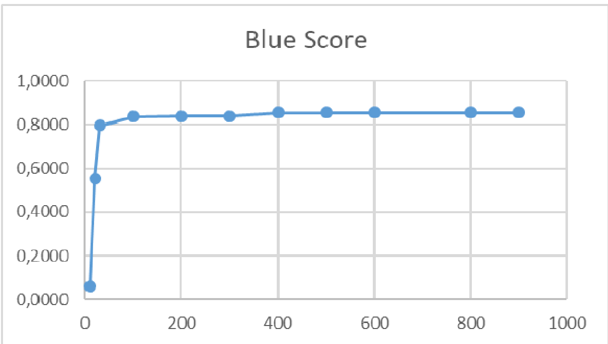

Figure 6 : Bleu Metric Scores Progress Diagram for the Proposed RBMT System

5. Conclusions and Future Work

The choice of a particular type of technology to process a language is greatly influenced by the density of the language, i.e., the availability of digitally stored resources. Commercial research and development have concentrated on high-density languages. Today GSL, like any other sign language, is a low-density or under-resourced language. Because of modality, acquisition of sign language data is a time consuming and expensive task, compared to the acquisition of spoken or written data. Currently there is not any parallel corpus of sufficient size for GSL, which could enable data-driven approaches to machine translation in non-restricted domains. Additionally, the few existing works on the area of creating and analyzing GSL Corpus are copyrighted and thus not open to the researchers or the Deaf communities.

On the other hand, GSL, as all other SLs in the world, is not standardized, and GSL's full grammar has not been published yet. Only some recent works point out important grammar points, lines and references [11], [13], [16], [28]. All these problems make the development of a RBMT system "supervised by a professional translator" the only viable solution. In this case the translator will be enabled to create large, parallel, quality, Greek to GSL corpus, without the need of grammar knowledge.

Finally, many other important aspects have not been addressed in this paper, and there is still a great deal of work to do. In particular the proposed system should be tested: (a) by a Statistical Machine Translation engine like MOSES [27], (b) in other thematic areas, by gathering large relevant corpus, and (c) in the field of other SL synthesis (animation), using other animation technologies and motion captures technologies in order to have more realistic animation motion of SL and speed up the creation of multimedia dictionary database.

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