Appendix A: The paper

A Proposed Semantic Machine Translation System for translating Arabic text to Arabic sign language

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ABSTRACT

Arabic Sign Language (ArSL) is the native language for the Arabic deaf community. ArSL allows deaf people to communicate among themselves and with non-deaf people around them to express their needs, thoughts and feelings. Opposite to spoken languages, Sign Language (SL) depends on hands and facial expression to express person thoughts instead of sounds. In recent years, interest in automatically translating text to sign language for different languages has increased. However, a small set of these works are specialized in ArSL. Basically, these works translate word by word without taking care of the semantics of the translated sentence or the translation rules of Arabic text to Arabic sign language. In this paper we will present a proposed system for translating Arabic text to Arabic sign language in the jurisprudence of prayer domain. The proposed system will translate Arabic text to ArSL by applying ArSL translation rules as well as using a domain ontology.

Categories and Subject Descriptors

J.5 [**Arts and Humanities**]: *language translation, linguistics.*

General Terms

Performance, Design, Languages.

Keywords

Accessibility, Semantic translation, Arabic sign language, SignWriting, Rule-based approach, Ontology**.**

INTRODUCTION

There are 17 million deaf people in the Arab world and 88,000 deaf people in Saudi Arabia alone [1]. Arabic Sign Language (ArSL) is the native language for many Arab deaf people. Also, Deaf people are facing many difficulties when communicating with other hearing people and in education, because there are limited resources of information written in their language. As a result, an automatic translation system from Arabic text to ArSL can help in making information and services accessible to the Arab deaf community. Previous work in translating Arabic text to ArSL are very few, most of these research worked only on translating words to signs and did not take care of the semantics of the translated sentence or the translation rules of Arabic text to Arabic sign language. To resolve this problem, we aim in our research paper to enhance previous research in this field by adding an extra layer of semantics while translating Arabic text to ArSL, this solution is aided by the power of semantic web technologies. Our proposed semantic translation system is limited to jurisprudence of prayer, because it is a small domain with limited vocabulary and it is really needed by our Arab deaf Muslims.

The main objectives of pursuing such a solution is: (1) to enhance Arabic text to Arabic sign language translation using the power of semantic web technologies (i.e. ontologies) and (2) to advance the research in the domain of automatic Arabic sign language translation.

The organization of the paper is as follows: in section 2 we present a brief background of SL, ArSL, notation systems and Ontologies. In section 3 we discus previous research in translating text to SL in different languages. In section 4 we present our proposed system architecture and evaluation criteria. Finally, in section 5 we conclude the paper with future work.

BACKGROUND

1. Sign language

In the last century, Sign Language (SL) has gained increased attention and universal recognition by many scientists in the field of language and computer sciences. This is because SL is considered the Native language of the deaf community and they can express their needs and the formation of concepts through it. As spoken languages use throat, nose and mouth as articulators, also SL uses fingers, hands, arms and facial expressions. These articulators can be classified as phonemes articulators similar to

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those used in spoken languages that occur simultaneously, however they are linear and sequential in spoken languages [2].

Sign language differs in different regions and countries, but they all agree on several things regarding the sign basic parts such as Manual Features (MF), Non-Manual Features (NMFs) and also they agree in defining the Signing space. Manual Features are signs performed by one or both hands using different shapes, locations, movement and orientations to represent meaning. NMFs are those features that do not involve hands and are used to give meaning and/or feeling or represent the morphological and syntactic markers of a sentence [4]. Movements of body parts such as head and shoulders, eye movements, eyebrows and facial expression like puffed checks and mouth pattern, are kinds of NMF. Signing space is the space or the private area surrounding the signer used to express signs in the sign language. This area extends from the top of the head to the waist level and extends by the length of the signer arms [2].

2. Arabic sign language

Arabic Sign language is different in each Arab region or/and country with many dialects. This difference gives the difficulty of communicating and dealing between deaf people in different Arab countries.

A need appeared to unify Arabic sign language in all Arab countries. This derived the Council of Arab Ministers of Social Affairs (CAMSA) to take a decision of developing a unified Arab sign language dictionary and publish it to all countries, in an attempt to help Arab deaf people to have a common language in addition to their local language [3].This dictionary is mostly used in education and in common communication such as sign language interpreters in television.

Arabic sign language like other known sign languages depends on three basic factors that are used to represent the manual features: hand shape, hand location and orientation. In addition to the non-manual features that are related to head, face, eyes, eyebrows, shoulders and facial expression like puffed checks and mouth pattern movements. ArSL is limited to represent nouns, adjectives and verbs. Prepositions and adverbs are represented in the context of articulation by specifying locations, orientations and movement. Intensifiers represented by iteration [5]. Signs forming and sequencing in the articulation, are done depending on the Arabic sign language grammar and rules.

3. Transcription and notation systems

Sign language is represented visually and it cannot be read as other written languages. There are few attempts to write sign language, however all of these attempts are not usable because of their weakness. They also contain symbols that are difficult to understand and learn.

We will give a brief overview of the ways to write SL in notation system for the purpose of using it in machine translation.

Stokoe notation was developed in 1960 by William Stokoe, it is written using symbols similar in the form to English alphabet symbols [6]. Figure 1 shows an example of Stokoe notation for the word "story": B means flat hand shape, a mean palm facing up, z means side to side "means both of right and left hands are side to side " and ~ means up and down.

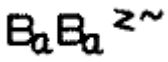

Figure 1: Stokoe Notation example for: "Story" word [7]

HamNoSys was developed in 1989 by Hamburg University Research Group .The root of this system is Stokoe Notation in addition to set of parameters set at the end of the word representation such as: shape, location, orientation, extended finger orientation and movement of both dominant and the non-dominant hands in addition to NMF representation [11]. Figure 2 shows an example of HamNoSys notation for "Oh! Look! There!" sentence: Means hand shape with extended Index finger, Means that hand orientation is away from the body, means that palm of the hand is facing down, means hand location in the front of the signer neck.

Figure 2: HamNoSys notations example for: "Oh! Look! There!" sentence [9]

Gloss notation: is a textual representation of sign language used for transcribing sign language video sequences [12].**Sign Writing** was developed by Valerie Sutton in 1974 [13]. Symbols used in this system are pictures that are similar to the real forms. Figure 3 shows an example of SignWriting notation for the word "girl" where Means the head of the signer and the shaded parts means the hair of the signer, means hand with the index finger pointing out and the shaded square means that the back of the hand is facing outward, means the points in the face that the signer must touches by his index finger and means that the motion of the hand is downward.

Figure 3: SignWriting notation example for: "girl" word [45]

TABLE I
SUMMARY OF NOTATIONS SYSTEMS

	Stokoe	Gloss	HamNoSys	SignWriting
Representation	Symbolic	Textual	Symbolic	Symbolic
Language dependency	language-dependent	language-dependent	language-independent	language-independent
Uses	Intermediate representation in the MT	Intermediate representation in the MT	Intermediate representation in the MT	Intermediate or final representation
Usability by Deaf	Not practical	Not practical	Not practical	Practical
Way of Writing	Horizontally (from left to right)	Multi level	Horizontally (any order)	Vertically (from top to bottom)
Number of symbols	~55[7]	-	~210[10]	~639[14]
NMF	Not Supported	Supported	Supported	Strongly supported

As we can see from TABLE II, SignWriting is the best choice for our system, it is a language independent, contains large number of basic symbols that can give a chance to build a large number of final symbols, it has a better support of NMF, it is understandable, practical and it is usable from the deaf people in their daily life such as education, communication, reading.

4. Ontology

There are many definitions of ontologies; Studer et al. [22] defined ontologies as:

> *"an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon. Explicit means that the typeof concepts used, and the constraints on their use are explicitly defined. Formal refers to the fact that the ontology should be machine readable. Shared reflects the notion that an ontology captures consensual knowledge, that is, it is not private of some individual, but accepted by a group"*

Ontologies are so important nowadays to share common understanding of the domain knowledge and to know how knowledge is structured and related to each other. Also, it is important to help in reusing these knowledge artefacts.

Ontologies can be classified according to [24] into two dimensions: (1) the amount and type of structure of the conceptualization and (2) the subject of the conceptualization. The first dimension is classified into three categories: (1) Terminological ontology designed to represent terms that are used to represent knowledge in certain domain such as lexicons, (2) Information ontology designed to record and structure the database of a certain domain, and (3) Knowledge modelling ontology designed to specify the conceptualizations of the knowledge.

The second dimension is classified into four categories: (1) Application ontology designed to model knowledge required for specific application, (2) Domain ontology designed to represent knowledge relevant to a certain domain, (3) Generic ontology designed to represent knowledge relevant to many domains, and (3) Representation ontology designed to represent a framework with a neutral view with respect to world entities.

In our system we will be representing the jurisprudence of prayer domain using a Domain ontology designed to represent knowledge relevant to this domain.

5. Sign Language Machine translation

Sign language machine translation follow two approaches: Rule based and Data driven approach. The Data driven approach, also known as corpus-based approach, can be

divided into Statistical Machine Translation (SMT) and Example–Based Machine Translation (EBMT) methodologies.

The Data driven approach requires a prerequisite corpus to work on it and the accuracy and quality of the transition depend on the corpus size. On the other hand, Rule-based approach, the second approach, is based on linguistic rules. It has two paths: direct path and indirect path. Direct path approach is used in bilingual

dictionaries that require translating a word to corresponding word only without any detailed analysis of the syntactic structures of the inputted text or any relation to the meaning of the words or relationship between them. Indirect path approach is the most sophisticated and widely used approach in machine translation. This approach is used to analyse the syntactic structure of the inputted text and create an intermediate or abstract representation of it and then generate a target language text from it, this means that we need to specify the word structure, sentence structure and semantic structure in successive processes [2].

According to the nature of the intermediate representation, indirect approach can be divided into Transfer-based and Interlingua-based methodologies. Transfer-based is a language-dependent, need to know the source and target languages. The analysis of the source language sentence is a shallow analysis and works on the syntactic level. Interlingual-based analysis is a deeper analysis of the source language sentence which creates structures of a more semantic nature. This structure can be transferred into language independent semantic representation that we can use to produce any target language translation. In our system we will follow the Rule-based approach for two reasons: (1) we do not have an Arabic corpus to work on and (2) no previous Arabic work followed this way.

LITERATURE REVIEW

Previous research in machine translation of written text to signed language follow two approaches, as mentioned in the previous section: Rule based and Data driven approach.

In our literature review we will focus on previous research that used rule-based approach for translating text to SL. In fact, there are a number of successful Rule based systems that translate text to sign language. We can divide these works into three groups, International research, Arabic research and SignWriting research.

International research is any work carried out to convert from Non-Arabic text to sign language. TEAM [28] and eSIGN [18] (essential Sign Language Information on Government Networks) are sample of two projects that translate English text to American SL. ViSiCAST [32] is another project that translate English text to British SL. Also, Zijl [33] developed a system to translate English text to South African SL. Baldassarri et al. [35] developed a system to translate Spanish text to Spanish SL. Dasgupta et al. [36] developed a system to translate English text to Indian sign language. Sarkar et al. [37] developed a system to translate Bangla text to Bangla SL. JEMNI and ELGHOUL [38] developed a system to translate a given text to SL for multiple languages.

Arabic research developed to translate Arabic text to Arabic SL is rare. For instance, Mohandes [39] developed a system to translate Arabic text into Arabic SL. This system is one stage in the process of developing a system to translate Arabic speech to Arabic sign language. The system has a database to store Arabic dictionary words with the corresponding signs and file names of the sign representation video. If the user enters a word that is available in the database then the recorded clip will be shown, if the word is not included then finger spelling is done. Similarly, Tawassol [40], is another Arabic system for translating Arabic text to Arabic SL. The system is used as an educational tool. It contains a translator, a dictionary of Arabic words for a set of categories, in addition to a finger spelling editor. The system uses Buckwalter Arabic Morphological Analyzer to analyse the inputted text and Vcommunicator Gesture Builder 2.0 with Sign Smith Studio program to generate the animation output.

As we can see from the previous work that the final output is either a video clip or an animated avatar, none have used SignWriting notation as an output, this does not mean that SignWriting is not usable. Actually, SignWriting is used in other applications either as a final stage of the translation or as an intermediate stage. For instance, the JSPad system [41] is used to write a Japanese sign language (JSL) using SignWriting. The system take a Japanese text then split it into signs, these signs are mapped to SignWriting symbols referring to the JSL dictionary then it display them on the screen to permit the users to edit the generated signs then add them to the dictionary. Likewise, Ahmed and Seong [43] developed a system for writing and reading text messages in signs as an alternative to SMS on mobile phones. The SignWriting notation system was used to convert text to sign message and sign to text message in two-way communication. Brito and Pereira [44] also proposed a model to support sign language content development and deployment in digital television scenarios by using SignWriting.

To further extend the research in SignWriting and Arabic text to ArSL translation, our proposed system will benefit from the two domains as we will describe next.

PROPOSED SYSTEM

Given the previous work in the domains of text to SL translation and SignWriting notation, our proposed solution will enhance previous techniques used to translate Arabic text to ArSL by considering ArSL translation rules and using a domain ontology to produce SignWriting notation. The SignWriting will be used as the final output of the system or as an intermediate level for future avatar animation.

Next we will describe in detail the components of our proposed system.

1. Domain Ontology component description

The domain of jurisprudence of prayer will consist of a set of classes in taxonomic (subclass) hierarchy, as follows:

- "دين" class is a super class of "دين إسلامي" class.

- "دين إسلامي" class has three sub classes:"عبادات","معاملات" and "أخلاق".
- "عبادات" class has three sub classes:"أركان","واجبات" and"مسنونات".
- "أركان" class has five sub classes:" نطق الشهادتين","الصلاة","الصيام","الزكاة"and"الحج".
- "الصلاة" class has a set of sub classes:"نافلة","فرض" and" أهل الأعذار", etc.
- "نافلة" class has a set of instances:"الوتر","السنن الرواتب" and " تحية المسجد","الكسوف","الخسوف","الجنازة","الضحى", "الإستخارة".

Also, there will be a set of properties for connecting classes and instances with each other, this include:

- Has.
- Is-a.
- Is a kind of.
- Is a synonym of.

Figure 4 illustrates an example of an ontology component.

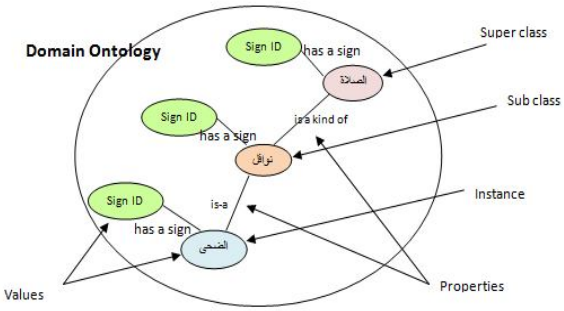

Figure 4: Ontology component illustration

System architecture

The architecture of our system is illustrated in Figure 5. The system is composed of a set of processes, namely: Morphological analysis, Grammatical transformation and Semantic translation.

Morphological analysis: This process takes Arabic text as an input and sends each sentence to the Morphological Analysis and Disambiguation for Arabic (MADA) tool for Part of Speech (POS) tagging. MADA returns a feature line for each word in the inputted sentence, feature line consist of a set of <feature>:<value> pairs. Word features such as (Gender, Mood, Case … etc), POS (Nouns, Verbs, Adjectives, Pronouns … etc) and proclitic (the word, question, conjunction, preposition... etc), enclitics associated with (person, gender, number), the rest include the diacritic form (diac), the lexeme/lemma (lex), the Buckwalter tag (bw) and the gloss (gloss) [12].

Grammatical transformation: The grammatical transformation process takes the previous results as input and applies the Arabic Sign Language rules on each word depending on its feature.

Semantic translation: This process takes the result of the previous process and search for each word in the Domain Ontology to get the word sign code. If the word does not have a corresponding sign then replace this word by one of its synonyms that have a sign in the SignWriting Database (DB). Then, replace each sign code by the corresponding sign symbol stored in the SignWriting DB. If the word does not have a corresponding sign in the domain ontology, it will be finger spelled.

EVALUATION CRITERIA

Based on our literature review, experts' evaluations have been used widely to evaluate the translation result, e.g. [21],[22]. The reason is that the translation can take different correct ways, only the experts of the Arabic Sign Language can decide upon its check their accuracy, (2) ask experts to translate a set of sentences manually and compare their results to our system translation results.

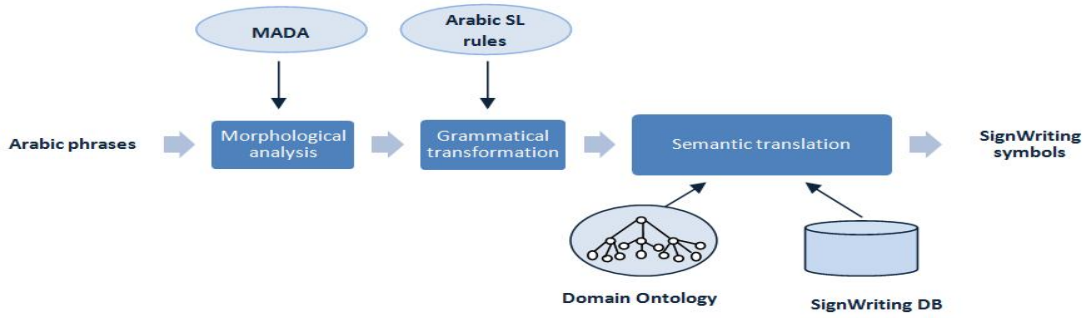

Figure 5: Proposed system architecture

CONCLUSION

This paper presents a proposed semantic translation system for translating Arabic text to ArSL using ArSL rules for grammatical transformation and domain ontologies for semantic translation.

In order to check the feasibility of our proposed system, we have limited the domain to the jurisprudence of prayer. We plan to evaluate this system based on two evaluation methods: (1) translate a set of sentences automatically then allow an ArSL expert to check its accuracy and (2) ask ArSL experts to translate a set of sentences manually then compare their results to our system translation results.

The logical next step is to build and evaluate our system in order to assure its consistency and correctness.

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