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A Roadmap to Elevate Pakistan Sign Language among Regional Sign Languages

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ABSTRACT

Several nations have worked hard to make their societies truly inclusive by developing gadgets, tools, services, and applications. A lot of work has been done for bringing the deaf community to the mainstream. Tools and applications exist for several sign languages including American Sign Language (ASL), Chinese Sign Language (CSL), Indian Sign Language (ISL) and Arabic Sign Language (ArSL). These tools help translating natural language text into respective sign language and vice versa. Similarly, standard corpora exist for all afore-mentioned sign languages and for many other languages. Unfortunately, no such noticeable development exists in the case of Pakistan Sign Language (PSL). This research aims to define a roadmap for the development of Pakistan Sign Language so as to bring it at par with other sign languages of the world.

Key Words: **Pakistan Sign Language, PSL, Sign Language, Parallel Corpus, Sign Language Translation**

Introduction

The deaf community all around the globe uses a language of gestures, known as sign language. Every country has its own sign language (Linguistic Society of America, 2018). For instance, the sign language for the USA is called American Sign Language (ASL), likewise the one used in the UK is British Sign Language (BSL), similarly, Indian Sign Language (ISL), Arabic Sign Language (ArSL), Chinese Sign Language (CSL) are other sign languages. Pakistan Sign Language is known as PSL.

Sign languages differ from the scripted languages as they employee hands for performing different actions, where each action represents some word or phrase. The sentences of sign language are strictly different from the sentences of written languages as they do not require articles and prepositions etc. without which the written languages cannot convey the meanings. Therefore, in order to facilitate the deaf community many researchers in the developed countries have worked on designing tools and technologies that help the deaf people communicate with the normal ones. Many tools, applications, and services exist for ASL and BSL. Whereas, in Central and South Asian regions a noticeable work has been done on ISL and CSL. But, unfortunately, no significant work has been done on PSL as we struggle to find any formal information about the language ingredients and its grammar. Similarly, there are no tools or services to support the deaf community of Pakistan.

Let us consider the following motivational example to understand the idea of this research and its possible impact on the society. Think of a hearing impaired student whose teacher has given him lecture notes in a file. He needs the help of an interpreter to understand the lecture. However, it will be of great help for him if he has a translation system that takes natural language as input and shows the gestures of respective sign language, PSL in this case. This application will work as a virtual interpreter for him.

Similar tools can be developed to effectively teach the hearing impaired students to facilitate the schools providing special education. Another possibility can be installation of such customized tools at different kiosks at airport, bus/train terminal and super markets etc. through which we may be able to communicate with the hearing impaired people.

This research provides a roadmap to develop such tools and services for Pakistan Sign Language so as to rise its rank among other sign languages. To this end, it provides high level milestones to be achieved including a parallel corpus, a translation system, an avatar generation system, and in the end combining them all to design and develop applications to facilitate the deaf community of Pakistan.

Related work

Several corpora exist for different sign languages for the world. (Schembri et al., 2013) present BSL corpus. Almohimeed et al., (2010) have compiled a corpus for Arabic sign language. (Zafrulla et al., 2011) present a corpus for ASL. Östling et al., (2015) have worked on enriching Sweedish sign language corpus. Prinetto et al., (2011) provide a sign bank for Italian Sign Language. The purpose of these corpora is to provide a standardized version of the respective sign language. Similarly, different manifestations of a word can be used by human and machines for learning. The machine readable formats allow to develop systems that help

rendering respective gestures in different ways, for instance, in the form of an avatar.

Natural languages are being translated to sign languages and vice-versa since early 2000. Some initial work in this regard was done on ASL by Grieve and Smith Grieve-Smith, (2002) (Speers, 2002), Zhoa et al.(2000), and Huenerfauth, (2004). Some recent work is presented by Rogers et al., (2015) Jin et al., (2016) have worked on BSL and ASL translation systems. Suszczanska et al., (2002), Bungeroth et al., (2004), San-Segundu et al., (2008), Porta et al, (2014) have worked on different European sign languages including BSL, Irish, and Spanish sign language. While Van Zijl et al., (2003) worked on machine translation of South African sign language. In our region Luqman and Mahmoud, (2018) El-Gayyar et al., (2016) present an automatic method for translating Arabic text to Arabic sign language. Hoque et al., (2016) have presented an automatic translation system for Bangla sign language. Similarly, Mishra et al., (2017) have presented their work on natural language to ISL. A survey of different methods and approaches used for natural language to sign language translation has been presented by Goyan and Goyal, (2016).

The other aspect of this translation is to recognize sign gestures and translate them to natural language. Technically speaking, this is more difficult than the previous one. Different researchers have used some hardware devices including Kinect, gloves, sensors along with software systems to identify gestures for different sign languages Mohandes et al., (2007). Alternatively other researchers have relied upon computer vision approaches that involve image processing of video recordings obtained by digital cameras to identify gestures performed by a signer Rashid et al., (2009). An elementary work has been done by researchers of PSL in both these directions, as a system named "Boltay Hath" which recognizes PSL gestures using data gloves has been developed by Alvi et al.,(2004). While, Khan et al., (2014) have proposed a vision based approach to recognize PSL alphabets.

Proposed methodology

The proposed research aims to use Information Technology to minimize the gap between the deaf and normal people in Pakistan. The existing work for the development of PSL as language is already not sufficient, and needs a serious attention. To bridge the aforementioned gap between hard of hearing and a normal person, we anticipate the need of a system which can translate Natural Language to Pakistan Sign Language. Till now interpreters have been doing this work but in this project it isintended to automate this process as much as possible. Unfortunately, very little work is done on natural language to Pakistan sign language conversion. The only reasonably structured effort is available at (www.psl.org.pk) which only contains videos of commonly used words of PSL.

These videos may only help in learning the gestures, but cannot be effectively used in building automated tools and applications for the deaf community.

Design/selection of language translation architecture/approach

There exist many (machine) language translation architectures. As discussed in the literature review section, following are some of the widely used architectures/approaches:

- Direct translation
- Translation through an intermediate language (Interlingual Translation)
- Transfer based architecture for translation
- Statistical model based architecture

The first approach is the direct translation, which is the most basic form of transfer i.e. word-to-word replacement. It is important to note that word order of the target language is maintained the same as the source language in this architecture.

Second approach is the most degenerate form of transfer, i.e., source-language text should be transformed into an Interlingua (an abstract language-independent representation). The target language is then generated from that Interlingua.

The third approach, transfer based architecture for translation augments the Interlingual translation by involving a transfer function which transforms Interlingua of the source language to the Interlingua of the target language. In order to use this approach, we need some "linking rules" that map between the source language text and target language text. It is a costly process as we have to maintain the semantics of the source language.

The fourth approach makes use of statistical models to translate the sentences from the source language to the target language. In this approach, the sentence structure is predicted based on the previously recorded (historical) data.

Direct and interlingual machine translations are difficult because of their inability to maintain the semantics, and hence are not suitable for a wider domain. The statistical model based approach is highly dependent on the sample data and favors the sentences and words which are frequently appearing in the dataset. Transfer based Machine translation seems to be the better choice, as it is more generalizable and extendable since it makes use of a set of linking (transfer) rules. Furthermore, unlike the direct translation approach it accommodates mappings and operations, such as, swapping the object and the subject and elimination of articles etc. The flexibility and extensibility of this approach lies in the fact that we may add more rules to the system seamlessly, or change any existing rules to refine them.

After a careful analysis and contemplation on the various possible architectures, we have opted to use transfer based methodology for our system. As,

we cannot go for statistical models for translation in the absence of the very data required to model the translator. This approach will give us a good start like Zhao et al., (2000) did for English to ASL translation. To this end, we would be aiming to define an intermediate representation from the input sentences utilizing the word order, types of sentences, and the morphological structure of the input sentence, and generate corresponding PSL sentence structure using the transfer rules define for PSL. Figure 1 shows the major activities to accomplish the work in the proposed project. These activities are explained below:

1. Development of standardized parallel corpus by contextual inquiry

i. Data Collection for analysis
ii. Building a parallel corpus (includes different representation of a word) of Pakistan Sign Language.
iii. Define and apply a process to standardize the contents of the corpus.

2. Development of PSL grammar

i. Building a grammar for Pakistan Sign Language sentence structure.
ii. Evaluate the correctness of the defined grammar.

3. Automated translation and visualization of English sentences into PSL gestures

i. Development of a software system to automatically translate an input English language sentence into equivalent PSL sentence.
ii. Animate the PSL sentence using an avatar by incorporating the standard gesture repository built in 1st step.

4. Demonstration of the effectiveness of framework through a case-study

i. Design and Develop a useful prototype software system for a certain domain (e.g. class-room teaching) using the whole framework.

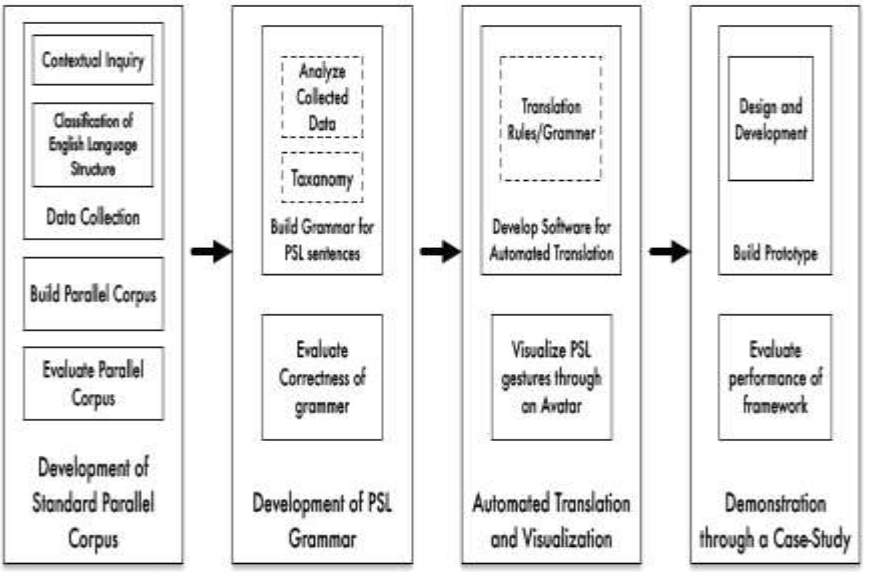

Figure 1: Major Activities of the Proposed Work

1. Development of standardized parallel corpus by contextual inquiry

Contextual inquiry is a semi-structured interview approach to gather data about the use of context, where the interviewer speaks to the interviewee, aiming to gather as much data as he/she can for later analysis. To this end, we aim to start with the New General Service List (NGSL 2017) for English language that has a few thousand most frequently used words. The involved subjects and interpreters will help gathering this data through a well-defined process.

i. Data collection for analysis: In order to build the parallel corpus, first we need to understand the syntactic and semantic formation of English sentences and PSL gestures. Following are the details of our analytical process:

Scrutiny of English Language: In this phase we shall have a critical examination of English language in terms of its structure and sentence formation.

Taxonomy of English Language: After a keen observation of the English language structure we intend to know the basic classification of English language structure, and shall define a useful classification on the basis of structure, meaning and tenses, etc.

On-site interviews and survey to collect PSL data corresponding to the above **Taxonomy:** Carrying on this structured approach, we shall gather some sample data, categorized into above mentioned classifications. In this data collection phase, we shall develop some questionnaires (modeled on the above taxonomy) and get them filled by involving the subjects and the interpreters involved in this study. We shall also make use of contextual inquiry, i.e., semi/un-structured interviews for a more flexible data collection as our interview depends on the respondent's answers, allowing the respondent to talk in some depth about the translation of English Language to Pakistan Sign Language. This approach will increase the validity of our data as it will provide the interpreters with an opportunity to probe for deeper understanding. We would also involve a linguist consultant for covering all the perspectives of this work.

ii. Building a Standard Parallel Corpus for PSL: This part aims to process the collected data to build a parallel corpus of PSL letters, words, and phrases which not only contain their respective videos, but also contains their representation in richest sign writing notation e.g. HamNoSys, so that it may be used by a machine to process and help in building software applications. This leads to the first tangible outcome of our work i.e. a parallel corpus for PSL. It is pertinent to mention here that we intend to build and store this corpus in the form of a database which should be useable for the software components of the system wherever required. Furthermore, we shall create a website for exposing this data for different users.

iii. Evaluation of Parallel corpus for PSL: Furthermore, we need to ensure the standardization of this corpus, to this end, we intend to involve the Sign Language experts to work as editors for the built corpus and ensure that the gestures are correct, and would help resolving the conflict, if at all they arise during the data collection phase.

2. Development of PSL grammar

After building the corpus, the next step will be to use the collected data for English to Pakistan Sign Language conversion. Exploratory analysis of the corpus would lead us towards inferring translation rules for this conversion.

i. Defining the PSL grammar: Once we have the corpus, we then need to build the middleware shown in Figure 5. To this end, the scope of the proposed project is to convert NL to PSL, and for that matter, we need to define a grammar for PSL which shall in turn be used to convert NL sentences to PSL equivalent sentences. Till now no free standard written grammar exists for PSL nor has much progress been made in this field. Therefore, defining a grammar would be the next

important task. Now, in order to define the grammar for PSL we first need to devise a process to define this grammar, and then follow this process to define it.

ii. Evaluation of PSL Grammar: Once the grammar is defined it needs to be verified and tested. In order to complete this task correctly and amicably we would be needing the services of a linguist as a consultant. The correctness of this part of the project is important as the translation module is going to be dependent on the grammar being defined in this phase. Therefore, a correct and verified grammar would ensure the correctness of the language translation module.

We intend to define a process for evaluating the effectiveness of the proposed grammar in two different ways. Firstly, by testing it on different types of NL sentences by involving the taxonomy of English language generated earlier. This will not only help in assessing the effectiveness of the proposed grammar, but will also help in refining the grammar rules. Secondly, we shall conduct a formal evaluation of the proposed grammar so that it is represented in a suitable format which makes it usable for software development and is free from any ambiguities.

3. Automated translation and visualization of English sentences into PSL gestures

It is the implementation section where we aim to build a software that shall be provided with an English sentence as an input and it shall convert it in PSL equivalent sentence.

i. Building a Software System for NL to PSL Translation and vice-versa: Once the corpus and grammar are in place, we would be in a position to start working on building a software system that takes input a natural language sentence and converts it into equivalent PSL sentence. This again involves language processing and would require defining the theoretical model for this translation, which would then be implemented as a software system. This system also needs to be verified and tested by the domain experts. Furthermore, the usefulness of the system will be gauged with the help of subjects involved in this study.

Apart from the testing and verification from the domain experts, this system also needs to be tested thoroughly by involving software quality assurance and testing practices as it mainly is a software system. This would involve people to test the developed system in a comprehensive manner. This in turn involves the design of test cases, and conducting the test scenarios to ensure that the system is working properly.

It is pertinent to mention that translation from PSL to natural language involves image processing, or gadgets like Kinnect. Some basic work on PSL gesture recognition has been done so far. The proposed approach suggests to solve

this problem by imitating the previous work done by researcher on ASL recognition and translation to natural language.

ii. Visualization using an Avatar - PSL to Gesture Generation: Once we have the PSL sentence, we intend to build an avatar that would perform the gestures of this sentence using the parallel corpus defined earlier. Here, the machine readable format of PSL gestures would facilitate the software system to generate the required avatars in a standard way. Furthermore, it would be far more efficient, flexible, and seamless as compared to rendering the stored videos, which involve many different people of different ages and genders.

Again, being a software component of the proposed project, this component of the system also needs to be tested as a software. Test cases need to be designed and executed to ensure that the system is working as per requirements. Different types of gestures are discussed in the beginning of the project shall be used to define test cases to ensure that simple and complex gestures are being generated correctly by this module.

4. Building Proof of Concept Application(s)

Building a proof of concept application that involves all the above components would be the next target. Some of these applications have already been mentioned in commercial objectives set for this study.

We would aim with the simplest scenarios first and would firstly target to translate a NL sentence into PSL and generate its avatar by involving the corpus, grammar, translation software, and PSL to gesture generation system.

Similarly, we would build a news text translator to PSL gestures for the deaf community to understand the news stories in the form of video gesture stream instead of reading the text.

Class-room environment facilitator application can also be generated so as to help as virtual interpreter for translating the lecture notes in NL to PSL and in turn, transforming the PSL sentence into visual gestures using the PSL to video gesture component of our system. Thus, helping the students understand the lecture through visual aid, instead of reading the text.

All these applications would be designed, implemented, and tested properly as a software system. Furthermore, these systems shall also be verified by involving the subjects and domain experts. At the same time, being a complete application we would be assessing the usability and usefulness of the applications so that these applications are effective and purposeful for the deaf community. Thus, they can be launched as a web service, desktop application, or mobile application.

We have managed to define the high level software architecture for designing and developing the proposed project, which has been presented in Figure 2. The storage layer would help saving the data in a database system which we refer to as

the parallel corpus for PSL. This involves the design of a relational database management system to store the parallel corpus efficiently.

The middleware component will use the corpus and grammar to translate the NL sentence to PSL. This translation module can be exposed in the form of web services or as API's. Based on these services and API's more applications can be developed. To name a few, we can see in Figure 5, there is an application for deaf to generate video gestures so as to read the newspaper by pasting text in an application which will convert NL to PSL and shall generate avatar for news story. Similarly, another mobile application can be developed where a deaf is generating avatar for the short messages received in his cell phone.

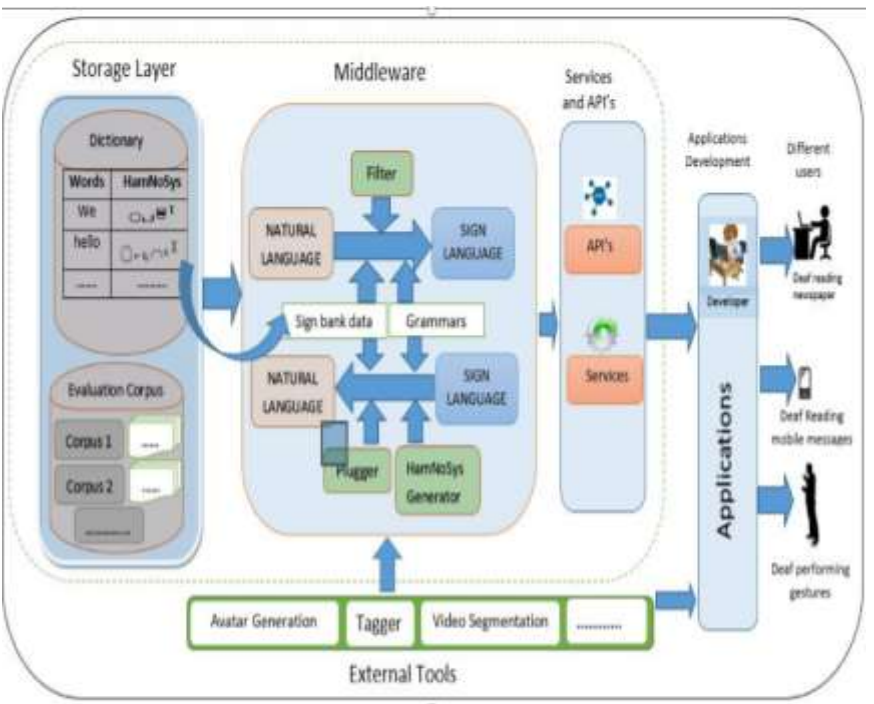

Figure 2: High Level Software Architecture (Khan et al., 2015)

Conclusion and future directions

Pakistan Sign Language is a language used by the deaf community of Pakistan. PSL is linguistically under studied language as compared to many of other sign languages. So far, no standard corpus of PSL exists, and also there do not exist any application that help translating natural language to PSL or vice versa. However, the literature survey reveals that significant work has been done on ASL, BSL, and CSL. Noticeable work has also been done on regional sign languages including

ISL and ArSL. Therefore, this work provides a roadmap of research work that can bring PSL at par with other sign languages with the help of building a standard parallel corpus for PSL, and with a system that will help translating natural language to PSL and vice versa.

In future, we intend to work on developing this corpus that will contain PSL letters, words, numbers, phrases and their videos, avatars, and written scripts in most suitable sign writing notations. We also plan to develop natural language to PSL translation system using transfer based architecture for machine translation.

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