Computer Science

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BRIDGING THE COMMUNICATION BARRIER FOR THE DEAF IN PAKISTAN ...

N. S. KHAN

Ph D

2019

BRIDGING THE COMMUNICATION BARRIER FOR THE DEAF IN PAKISTAN

USING INFORMATION TECHNOLOGY

Nabeel Sabir Khan

14007091001

Doctor of Philosophy in Computer Science,

Supervised by: Prof. Dr. Adnan Abid

2019

University Of Management & Technology, Lahore

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Bridging the Communication Barrier for the Deaf in Pakistan Using Information Technology

Nabeel Sabir Khan

14007091001

Submitted in the partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Computer Science, University of Management and Technology, Lahore.

Supervised by: Dr. Adnan Abid

2019

University Of Management and Technology, Lahore

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No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Department of Computer Science in partial fulfillment of requirements for the degree Doctor of Philosophy in the field of Statistics, Faculty of Social Sciences, National College of Business Administration and Economics, Lahore.

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University of Management and Technology	**PhD Scholar**

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ABSTRACT

The deaf community in the world uses a gesture-based language, generally known as sign language. Every country has a different sign language; for instance, USA has American Sign Language (ASL) and UK has British Sign Language (BSL). The deaf community in Pakistan uses Pakistan Sign Language (PSL), which like other natural languages, has a vocabulary, sentence structure, and word order. This research involves exploiting natural language processing (NLP) techniques to support the deaf community by proposing a novel machine translation model that translates English sentences into equivalent Pakistan Sign Language (PSL). The proposed approach involves a structured process to investigate the linguistic structure of PSL and formulate the grammatical structure of PSL sentences. These rules are then formalized into a context-free grammar, which, in turn, can be efficiently implemented as a parsing module for translation and validation of target PSL sentences. The whole concept is implemented as a software system, comprising the NLP pipeline and an external service to render the avatar-based video of translated words, in order to compensate the cognitive hearing deficit of deaf people. Quantitative results reveal a very promising Bilingual Evaluation Understudy (BLEU) score of 0.78. Subjective evaluations demonstrate that the system can compensate for the cognitive hearing deficit of end users through the system output expressed as a readily interpretable avatar. Comparative analysis shows that our proposed system works well for simple sentences but struggles to translate compound which warrants future ongoing research.

Index Terms: Deaf community, natural language processing (NLP), Pakistan sign language (PSL), sign language, software.

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DEDICATION

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I dedicate this Thesis

to my parents especially my (Late) Mother who I wish had seen this day,

Brothers, Loving wife ,caring children, Friends and to my teachers

whose guidance and support

enabled me to enlighten my life

with knowledge and virtue.

ACKNOWLEDGEMENT

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The whole praise to ALLAH, the ruler of the universe, who made me the super creature; blessed me with knowledge; and enabled me to accomplish this task.

No words to describe my sweet sensations of respect to my parents, because without their shadow of love, perhaps, it could have not been possible to attain this target. I am indebted to my Father, who enabled me to face the life with confidence, and whose bold commitments and ever increasing appreciations helped me in achieving my ambitions. I believe that the affection and prayers of my late mother have a significant contribution in the progression of my career. I also cannot forget my loving brothers, who have been encouraging me throughout my academic career.

I express profound gratitude to my supervisor Dr. Adnan Abid for his valuable suggestions, positive criticism throughout my research work, which has helped me polishing my research skills. Also my co-supervisor Dr. Kamran Abid, who is a good guide, and has been so affectionate and cooperative during this research, and has been encouraging and solacing me through all thick and thin during the course of this research.

I am also thankful to my friends Yaser Daanial Khan, Aizaz Akmal, Rana Waqas and Mohtashim Siddique for their moral support, critical discussions and nice company.

I would like to offer a very special thanks to my uncle Muhammad Khalid Khan, who has been regularly calling me to inquire how I was getting along with my research work and thesis.

This work would have not been possible without support and patience of my loving wife and children who have been very cooperative and tolerant during my long stays and night sittings at work place.

TABLE OF CONTENTS

LIST OF TABLES

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Tables

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LIST OF FIGURES

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CHAPTER 1

I. INTRODUCTION

A. Introduction and Orientation

Language comprises of verbal and nonverbal behaviors. Verbal proficiency enables human beings to communicate in an appropriate manner with each other. A grand total of our population encompasses acoustic, auditory and articulator tribes. Apart from them, there lies a forth tribe of language speakers, a considerable segment of population in the world suffers from hearing/speech disability. There lies an enormous communication gap between these disabled and the normal people. To bridge this gap, a language of gestures which is known as sign language exists. Sign language is comprised of gesticulation. According to a survey around 15 to 26 % of the world population suffers from some kind of hearing disabilities [1]

Spoken languages vary region to region and about 6,909 [2] spoken languages exist in the world till now. Similarly, the languages of gestures (sign languages) vary from region to region and about 138 sign languages are known till today. Among them, American Sign Language (ASL) and British Sign Language (BSL) are based on English language. Whereas, Indian Sign Language (ISL), and Chinese Sign Language (CSL) are also among the well-known sign languages. The grammars of these gesture based sign languages differ from grammars of spoken or written languages. The reason is that gesture based languages involve shapes and concepts, whereas spoken and written languages involve words and grammar rules, thus, both types of languages have significantly different grammatical structures [3]

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B. Concepts Involved in the Sign Language

A sign language uses manual communication and body language to convey meaning, as opposed to acoustically conveyed sound patterns. Each particular sign represents a distinct letter, word, or phrase of the corresponding spoken language e.g. for the word "What" the sign in different Sign languages are shown in Figure 1.1.

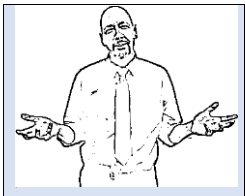		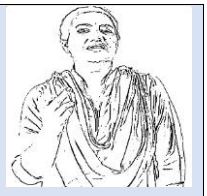
American Sign Language(**ASL**)	British Sign Language(**BSL**)	Pakistan Sign Language (**PSL**)

Fig 1. Sign of "what" in different sign languages

C. Gestures

Sign languages use gestures to make a sign for particular unit e.g. letter, word or phrase. These gestures are further broken down into manual gestures and non-manual gestures. Manual gestures consist of hand shape, movement, location [4] [5] ,and orientation as shown in Figure 1.2, whereas non-manual gestures consist of facial expression, head movement, posture and orientation of body shoulder raising, and mouthing, as shown in Figure 1.2. Mostly non-manual gestures are used along with manual ones.

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• For instance, if you have three figures in chapter I, the first figure in chapter II is simply Fig. 4, not Fig. II-1 or similar.
•The numbering of figures does not impact the numbering of tables, but each category is numbered independently – e.g., if you have three figures and then a table, that table is still Table I, not Table IV.

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CHAPTER 2

I. RELATED WORK

A. Overview

Machine translation has been an important subject in computer science for almost sixty years. During most of this time, however, machine translation for sign languages has been largely overlooked. It is only during the last decade that machine translation for sign languages received renewed interest. This is due both to advances in sign language linguistic research [6] [7] and to an increase in computing power. The proposed research aims to use Information Technology to minimize the communication gap between the deaf and hearing 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 generic machine translation framework which can translate Natural Language English in this case to Pakistan Sign Language and vice versa [14]. Section 2.2 presents the discussion on fundamentals of SL including various components involved in performing signs of different words along with types of signs on the basis of different morphological parts involved in the generation of a particular sign. Section 2.3 presents the discussion on different MT approaches. Related works of Machine Translation of text to sign languages have been discussed in section 2.4. Section 2.5 highlights the related work in the dimension of SL recognition using different approaches. Previous works related to various components involved in these machine translation systems including parallel corpus and grammar based translator have been discussed in Section 2.6. Lastly, on the basis of presented literature, Section 2.7 the research questions for this thesis have been presented along with the expected outcomes.

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B. Fundamentals of Sign Language

Sign language is a general term which includes any kind of gestural language that makes use of signs and gestures to convey message [15]. Sign language is known as '*language of gestures*' as well. It is a visual-motion language utilized by hard of hearing, people with hearing disabilities and deaf individuals as their mode of communication. Sign language which is a gestural dialect is influenced by spoken languages [16]. Sign Language is nearly an only mode of communication among people suffering from hearing impairment [19]. When a hearing impaired individual wants to say something, he/she performs some gestures to communicate. Each particular sign means a distinct letter, word or expression. Combination of signs makes a sentence just like words in spoken languages make sentences which are understood by normal and deaf people. Sign Language itself is a complete natural Language with its own syntax and grammar [16] [18]. There exist different sign languages like American Sign Language (ASL), British Sign Language (BSL), Indian Sign Language (ISL), Japanese Sign Language (JSL) and Pakistan Sign Language (PSL) etc…

1) *Components of Sign Language:* Sign Language is basically composed of two basic components or features: Manual and non-manual [16] [17] [18].

2) *Manual Features (MF):* The manual components of Sign Languages often include movement of hands which further includes Hand shape, Hand orientation, Location and Movement as shown in Figure 2.2.

   a) *Non-manual features* **:** Non-manual features described in Figure 2.4 include different facial expressions, head tilting / nodding, shoulder raising, and related …

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C. Hardware Based Approaches

1) *Glove Based*: A glove-based system is composed of an array of sensors, electronics for data acquisition/processing and power supply, and support for the sensors that can be worn on the user's hand [60]. In the 1970 first glove based system were designed and since then this technology is used in many fields such as design and manufacturing, robotics, medical/health care, and sign language understanding. The glove-based approaches [64] [65] [66] that are being developed in these years have different characteristics such as sensor types, the position of sensors, underlying recognition techniques, type of sign (static or dynamic) and accuracy [67] [68] [69] [70] [71]. Glove based approaches, along with sign language, the number of words, the total number of gesture dataset and accuracy is mentioned in Table 1.

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TABLE I

GLOVE BASED APPROACHES

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Approach	Language	Word	Total No. of Gestures (size)	Accuracy (%)
(Lee, Feb. 2018)	ASL	26 alphabets	6240	98.2
(Ambar et al., 2018)	ASL	9 commonly used words	-	Average sign detection time is 0.74 sec
(Kanwal et al., 2014)	PSL	10 words	300	90
(Lokhande et al., 2015)[26]	ISL	6 words	32	≈ 99
(Ma et al., 2000)	CSL	220 words and 80 sentences	300	(Ma et al., 2000)
(Swee et al., 2007)	MSL	25 signs	500	(Swee et al., 2007)

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TABLE I
LOREM IPSUM DOLOR SIT AMET

Ultrices	Diam	Mauris
Aliquam	478	3467
Mollis	367	265 *
Egestas	473	0
Volutpat	263	354
Imperdiet	4786	33

Non nisi est sit amet facilisis magna etiam tempor orci. Nisi scelerisque eu ultrices vitae auctor eu augue ut. massa tincidunt nunc pulvinar.

* Non curabitur gravida arcu ac tortor dignissim convallis aenean.

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CHAPTER 3

I. A TRANSLATION FRAMEWORK FOR PSL

A. Introduction

Machine translation has recently gained popularity and is being widely used to convert natural language (NL) text to a given sign language. A summary of relevant literature presented in Chapter 2 shows that an early work in rule based machine translation was conducted by [38]. A grammatical approach based on synchronous tree adjoining grammar has been proposed by [23], which has been further enhanced by [31]. Some of the latest work on rule based sign language machine translations are discussed in [106] [107] [108] [109] [110]. Another dimension of machine translation involves statistical machine translation of sign languages, some work in statistical machine translation of sign languages has been presented in [32] [36] [28] [103] [104] [105]. The main success of these systems depend on the size of corpus of both the source and target language. To the best of our knowledge no sentence level corpus of PSL exist so this is the main reason to first develop some rule based translation system which later can be used to generate corpus for machine translation systems. Likewise, example-based translation [102] is another variant of translating sign language to natural language [34] presents such translation for Irish sign language. Similarly, in South Africa a project South African Sign Language Machine Translation (SASL-MT) has been conducted to enable the deaf community of the country with the help of a machine translation system from English to SASL [35].

It is clear from the literature review that people and governments of many different countries have worked in many different facets to enable their hearing impaired population communicate with the normal people. Unfortunately, no significant work has been done for

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Pakistan sign language in this regard, and there is a great room for conducting research in various levels.

There exist several limitations and challenges in building a machine translation system to translate natural language text to Pakistan Sign Language gesture. Some prominent challenges are as follows:

- Lack of availability of linguistic information. PSL has not been linguistically investigated properly.
- Absence of Standard Sign corpus based on different language granularity units.
- No standard grammar rules for sentence creation in PSL.
- Automating it all requires evaluation and no evaluation corpus to test the system exists.
- No machine readable corpus for PSL exists.

CHAPTER 4

I. PSL CORPUS GENERATION

The framework for English to PSL translation was proposed in the previous chapter. The first layer of the proposed translation system is the storage layer comprising of the PSL parallel corpus. The literature review of existing SL corpora for different Sign languages as well as PSL is discussed in Section 4.1. Section 4.2 discusses about limitations of available PSL corpora. The need for Machine readable PSL corpus is described in Section 4.3. Discussion regarding various sign writing notations is presented in Section 4.4. The systematic process for PSL corpus generation is presented in Section 4.5. Section 4.6 highlights the effectiveness of the developed PSL parallel corpus.

A. LITERATURE REVIEW

1) Literature Review of Existing SL Corpora: There are various multilingual dictionaries having different kind of representations are available for different SL. Common representation media for SL corpora are picture based, video based and avatar based. Along with differences in their storage medium these dictionaries also vary in terms of language granularity level which they store. Among these some are word level i.e. they store word of a spoken language along with its representation in the corresponding SL, others store word and instead of storing sign either in picture or video they store the textual representation of the SL gesture using some sign writing notation. Some dictionaries are used in Statistical Machine Translation where instead of words sentences of both source and target languages are stored. The details of some of these different kind of corpora are briefly discussed as follows.

Spanish Sign Language- Spanish (DILSE) dictionary was proposed by [98]. It is a multilingual dictionary is available online for the deaf community of Spain. The dictionary provide

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two levels of search in which user can either search a Spanish word against a sign and similarly can do a sign search by giving a Spanish word as input [102] proposed a corpus for deaf children in Africa. The details of well-known dictionaries of ASL, BSL, ISL, ArSL have already been discussed in related work chapter of this thesis...

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CHAPTER 5

I. CONCLUSION AND FUTURE DIRECTIONS

A. SUMMARY

In this thesis, we have proposed a rule based Machine Translation framework for translating English language sentences into equivalent PSL sentences. To this end, a systematic approach has been used that involves data collection, analysis, and grammar rules generation to define the grammar for PSL. Later on, first ever PSL parallel corpus has also been generated by involving SL experts and deaf individuals. Finally, the translation system components have been integrated to produce end to end translation of English sentence to its corresponding PSL animations using avatar. The output of the system has been evaluated by two domain experts for the effectiveness and correctness of the translation system. The evaluation revealed that the system translated with approximately 95% accuracy.

The developed 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, corpus consists of English word along with its Urdu and roman equivalents. The signwriting notation HamNoSys. The human recorded videos as well as the videos generated by avatar were also stored in the corpus. 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 stored this corpus in the form of a database which should be useable as a reusable software component wherever required. Furthermore, a web interface is also exposed for this corpus to be accessed by different users for learning PSL. To the best of our knowledge this is the first computer process able PSL corpus which is easily extendable and can be used as a benchmark for future research in the domain of PSL…

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APPENDIX A

GRAMMAR

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If there is only one Appendix in the article, leave the Appendix unnumbered and unnamed as is.

Table C-1: PSL Grammar of Simple Present and Past Tense

Category of Sentence	PSL Grammar
Simple Present Affirmative	<SIMPLE-PRESENT-AFFIRMATIVE> ::= <SUBJ><VP><PRPS>| <NP1><NP2><VP> | <ADVP><SUBJ><VP>
Simple Present Negative	<SIMPLE-PRESENT-NEGATIVE> ::= <SUBJ><VP><"not">
Simple Present Interrogative	<SIMPLE-PRESENT-INTERROGATIVE> ::= <NP><ADJP><"Yes-No">
Simple Past Affirmative	<SIMPLE-PAST-AFFIRMATIVE> ::= <"was"><SUBJ><VP> | <"was"><ADVP><","><SUBJ><VP>
Simple Past Negative	<SIMPLE-PAST-NEGATIVE> ::= <"was"><SUBJ><VP><"not">
Simple Past Interrogative	<SIMPLE-PAST-INTERROGATIVE> ::= <"was"><NP><ADJP><"Yes-No">| <"was"><NP1><NP2><"Yes-No">

APPENDIX B

SAMPLE QUESTIONNAIRE FOR AVATAR'S EVALUATION

Table C-1: Questions asked for Avatar's evaluation

Comprehensibility	
Naturalness	How natural is the performance of the avatar? In case of problems please comment:
Selected Answers	Overall it is quite good, and interesting, but The stiffness of the avatar makes it uneasy. The idea of avatar is excellent, if you could improve the transition from one gesture to another.
Position	How well is the avatar utilizing the sign space?
Selected Answers	A big portion of body is being shown in the screen, only top area should be shown. Later on we rectified this issue. Subsequently, this problem was resolved.
Rhythm	Do you think that the speed of avatar is just fine?
Selected Answers	We managed to control the speed with the help of few deaf subjects. The gestures looks good, and the speed is just fine. Speed of avatar is OK.
Expressiveness	How comprehensively does the avatar express the gestures?
Selected Answers	The avatar is very good. Non manual features should be improved.

	Avatar is understandable.
Contrast and Emphasis	Are the colour and contrast of the avatar fine?
Selected Answers	The hands are of different colour so they are understandable. Colour combination is good. Easily to notice hands.

Usability

How do you rate your understandability of avatar rendered videos as compared to human rendered videos for the following different granularity levels?

- Word Level
- Sentence Level
- Paragraph Level

Average results have been reported in Table 6.1.

References

[1] J. Fellinger, D. Holzinger, and R. Pollard, “Mental health of deaf people,” *The Lancet*, vol. 379, no. 9820, pp. 1037-1044, 2012.

[2] S. R. Anderson, “How many languages are there in the world,” *Linguistic Society of America*, 2010.

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[4] H. A. Q. Maarif, R. Akmeliawati, and S. Bilal, "Malaysian Sign Language database for research." pp. 798-801.

[5] M. L. Hall, V. S. Ferreira, and R. I. Mayberry, “Syntactic priming in American Sign Language,” *PloS one*, vol. 10, no. 3, pp. e0119611, 2015.

[6] K. Hogan, *Can't get through: eight barriers to communication*: Pelican Publishing, 2003.

[7] "Ethnologue: Languages of the World," July 10, 2016; http://www.ethnologue.com/.

Commented [SA74]: •References should be provided on a separate page at the end of your paper, with the title “References” at the top of the page.
•References should be listed and numbered in order of citation, not alphabetically.
•The numbers should be flush left and separated from the body of the reference.
•Titles of books, journals, and publications are set in title case.
•Titles of articles, technical reports, and publications are set in sentence case.
• Names of months are shortened to 3-4 letters each: Jan., Feb., Mar., Apr., May, June, July, Aug., Sept., Oct., Nov., and Dec.

Additional Information about References with Examples

Books:

[#] Author,*Title*, volume, edition. City, State, Country: Publisher, year.

Commented [SA75]: •The basic format for a book citation.

Example:

[1] J. Haydar, B. Dalal and W. Fahs, *Sign Language Communications*, 2nd ed. Fort Worth, TX, USA: Harcourt Brace College Publishers, 1996.

[#] Author, *Title*, volume, edition. City, State, Country: Publisher, year. [Online]. Available: URL. Accessed: month day, year.

Commented [SA76]: • If the book was accessed online, add "[Online]", accompanied by the URL and date accessed.

Example:

[2] S.M, Lee, *Sign Language Device*, 3rd ed. London, UK: George Redway, 1896. [Online]. Available: https://books.google.com/books?id=azpHAAAAIAAJ. Accessed: July 1, 2019.

[#] Author, *Title*, Translator, Trans., Editor, Ed., volume, edition. City, State, Country: Publisher, year.

Commented [SA77]: • Translators and editors can be added after the title, identified by the abbreviations "Trans." or "Ed."

Example:

[3] G.J, Grimes, *Digital data entry*, J. S. Stallybrass, Trans., vol. 2, 4th ed. London, UK: George Bell and Sons, 2012.

[#] Author, "Chapter," in *Title*, volume, edition. City, State, Country: Publisher, year, chapter, section, page range.

Commented [SA78]: • To cite a specific chapter or section, add the title of the chapter/section before the book title, and include the chapter/section number and page range at the end. Use the abbreviations "ch.", "sec.", and "pp."

Example:

[4] C. Oz, Wearable Device", *Wearable Device for Sign Language Recognition*, 3rd ed. New York, NY, USA: Routledge, 2012, ch. 5, pp. 93–116.

Periodicals:

[#] Author, "Title," *Journal*, volume, number, page range, month year, DOI.

Commented [SA79]: • Journal article citation with DOI.

Example:

[1] D. Brentari, J. Fenlon and K. Cormier, "Sign language phonology", *Journal of Communication Inquiry*, vol. 42, no. 1, pp. 5-25, Jan. 2018, doi:10.1093/ /970165.013.117.

[#] Author, "Translated Title," *Journal*, volume, number, page range, month year, DOI. (Transl.: Translator, publication information)

Example:

[2] N. Nihei, "Reconsideration of the problem of complicity between volunteer activities and neo-liberalism,"*Shakaigaku Hyoron*, vol. 56, no. 2, pp. 485-499, Sept. 2005, doi: 10.4057/jsr.56.485. (Transl.: Q. H. Dinh, *International Journal of Japanese Sociology*, vol. 19, no. 1, pp. 112-124, Oct. 2010, doi: 10.1111/j.1475-6781.2010.01124.x)

Conferences

[#] Author, "Title," presented at the Conference, City, State, Country, Month days, year, paper number.

Example:

[1] I. Marshall, and E. Sáfár, "Extraction of semantic representations from syntactic SMU link grammar linkages". Presented at the 54th Int. Conf. on Medieval Stud., Kalamazoo, MI, USA, May 9-12, 2019.

[#] Author, "Title", in *Conference Proceedings*, Editor, Ed., City, State, Country, Month year, page range.

Example:

[2] J. Tumsri and W. Kimpan, "Thai sign language translation using leap motion controller". In *Proceedings of the International Multi Conference of Engineers and Computer Scientists*, H. Jones and J. Williams, Ed., Ludlow, UK, Oct. 2017, pp. 46-51.

Commented [SA80]: • An article that was originally written in another language but translated by someone else should have the translation information in parentheses at the end of the entry.

Commented [SA81]: •A presentation given at an academic conference.
•Conference names should be abbreviated.

Commented [SA82]: • Citing conference proceedings.
• Note that the date in this citation is the publication date given for the proceedings, not the time of the original conference.

[#] Author, “Title”, in *Conference Proceedings*, Editor, Ed., City, State, Country, Month year, page range. [Online]. Available: URL

[#] Author, “Title”, in *Conference Proceedings*, Editor, Ed., City, State, Country, Month year, page range, DOI.

Example:

[3] P. Deaf, “Welcome to Pakistan association of the deaf”, *Proc. 24th Australian Comput. Sci. Conf*. Gold Coast, Qld, Australia, 2014, pp. 78-84. [Online] Available: http://www.padeaf.org/publication.asp [Accessed: 04- Jun - 2019].

Example:

[4] J. H. Huang and D. Powers, "Large scale experiments on correction of confused words," *Proc. 24th Australian Comput. Sci. Conf*. Gold Coast, Qld, Australia, 2001, pp. 77-82, doi: 10.1109/ACSC.2001.906626

Thesis and Dissertations

[#] Author, “Title,” document type, Department, University, City, State, Country, Year.

Example:

[1] L. S. d'Armond, “Representation of American sign Language for machine translation,” PhD dissertation, Georgetown University, United States, Washington, 2002.

[#] Author, “Title,” document type, Department, University, City, State, Country, Year. [Online]. Available: URL

Example:

[2] J. Bungeroth, and H. Ney, “Barm, yeast, leaven, and the gesyfled loaf: an extended footnote to *Juliana* 396b,” M.A. thesis, Dept. English, Purdue Univ., West Lafayette, IN, USA, 2017.

Commented [SA83]: • If the source is found online, include the URL or DOI in conference references.

Commented [SA84]: With URL

Commented [SA85]: With DOI

Commented [SA86]: • If there is not a formally-published version of the work, but often the only way to access certain information is through repository copies of dissertations.

Commented [SA87]: • If you are accessing this thesis or dissertation in an online repository, you must also include the URL, but an access date is optional.

Websites

[#] Author. “Page.” Website. URL (accessed month day, year).

Commented [SA88]: Website citation format.

Example:

[1] P. Deaf, “Welcome to Pakistan Association of the Deaf”. Padeaf.org. http://www.padeaf.org/publication.asp (accessed Jun 4, 2019).

Manuals and Handbooks

[#] *Title*, edition, Institution, City, State, Country, year, page range.

Commented [SA89]: The citation format of a manual (Print form)

Example:

[1] *Pakistan Sign Language*, 3rd ed, Family Educational Services Foundation, Toyota, Aichi, Japan, 2016.

[#] Author. *Title*, edition. (year). Accessed: Month day, year. [Online]. Available: URL

Commented [SA90]: The citation format of a manual with “**author**” (Online)

Example:

[2] J. Bungeroth and H. Ney. *Statistical Sign Language Translation*, 2nd ed. (2015). Accessed: July 12, 2019. [Online]. Available: https://manuals.gogenielift.com/operators/english/1000031.pdf

[#] Institution, City, State, Country. *Title*, edition. (year). Accessed: Month day, year. [Online]. Available: URL

Commented [SA91]: The citation format of a manual with **“institution”** (Online)

Example:

[3] Population Census Organization, Lahore, Pakistan. *Genie Operator’s Manual with Maintenance Information*, 4th ed. (2017). Accessed: June 12, 2015. [Online]. Available: http://www.census.gov.pk/ index.php