

Shedding Light on the Underexplored: Tackling the Minor Sign Language Research Topics

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Abstract

In the past decade, sign language research has achieved remarkable results alongside advancements in deep learning. However, there is a disconnect between the outcomes of these research efforts and the actual use of sign language by signers. In this position paper, we reviewed sign language papers related to deep learning published in the last ten years to explore the reasons for this gap. We found many areas of research that are still underdeveloped, despite their linguistic importance. Based on an analysis of known corpora and methodologies, we identified the reasons for the lack of progress in these areas and propose directions for future research efforts.

Keywords: sign language research, underexplored research topics, sign language linguistics, communication methodologies

1. Introduction

We have seen many advances in sign language research with the introduction of deep learning. The most significant advances have been in recognition (Rastgoo et al., 2021a), translation (Kahlon and Singh, 2023), and generation (Rastgoo et al., 2021b). Despite severely limited resources, sign language research continues to make new advances every year.

Nevertheless, there are elements of sign language that are not studied despite being important linguistic elements (eye-gaze, topic, role-shifting, tensions, space allocation, depicting signs, buoys, etc.). These are important aspects of the language that are used in real life and should be studied if we want to make the results of sign language research practical.

In this position paper, we examine the elements of sign language linguistics, and investigate both actively researched areas and those that have received less attention. Furthermore, we propose why such studies are significant, discuss why certain studies have not been well-conducted, and what actions we should take to facilitate research in these areas.

2. Sign Language Linguistics

Sign languages employ visual-manual modalities, involving handshapes, movements, facial expressions, and body postures to convey meaning (Sutton-Spence and Woll, 1999; Valli and Lucas, 2000; Sandler and Lillo-Martin, 2006). This distinct mode of communication leads to unique linguistic structures, including phonology, morphology, syntax, and semantics, tailored to the visual-spatial

nature of sign languages. In this section, we delve into certain linguistic features that are more prominently highlighted in sign languages compared to spoken languages.

Space and simultaneity Sign languages are often referred to as spatial languages due to their inherent use of space to convey complex meanings. By exploiting the signing space with various articulators, signers can simultaneously present multiple pieces of information, a feature known as simultaneity (Geraci et al., 2008). For instance, signer use of buoys, which are handshapes or signs held in place to maintain a reference point or context while other signs are used to expand on other concepts, has been documented in various sign languages (Liddell, 2003; Tang et al., 2007). Simultaneous signs can represent actions, locations, or other descriptive information, allowing for a rich layering of language that is conveyed in a visually intuitive manner. This multi-layered approach to communication enables signers to present complex scenarios and narratives efficiently and effectively.

Topicalization Topicalization in sign languages involves the marking of a topic or the subject matter of a discourse at the beginning of a sentence or phrase, which is then followed by a comment or predicate about that topic. Friedman (1976); Aarons (1996) studied topicalization in American Sign Language (ASL) and Sze (2011) studied it in Hong Kong Sign Language (HKSL). This structure is often marked by specific non-manual signals such as raised eyebrows or a slight forward lean of the body, clearly distinguishing the topic from the rest of the discourse. This linguistic feature allows signers to structure their discourse in a way that

highlights the main points of discussion, making the communication clear and focused.

Role-shifting Role-shifting is a dynamic feature of sign languages where signers take on the roles of different characters in a narrative. Padden (1986) gave an early analysis of role-shifting in ASL and argued that its use is more than just play-acting. By physically shifting their body orientation, facial expressions, and gaze, signers can represent different perspectives and viewpoints within a story. Role-shifting adds depth to a narrative by allowing the signer to embody different characters, making utterances more engaging and easier to follow. This technique is not only a powerful storytelling tool but also a sophisticated linguistic mechanism for indicating changes in subject, object, and possessive relationships within a narrative.

Phonology Sign language phonology encompasses both spatial and temporal aspects of signing, a notable difference from spoken language phonology. Brentari (1998) explored both the simultaneity of ASL phonemes and asserted that movements are the most basic prosodic elements of ASL. Brentari (2011) later presented a thorough overview of phonology in sign languages, focusing on ASL but also drawing from studies on other sign languages. Much research has been devoted to exploring the building blocks of signing across different sign languages, usually focusing on articulator position, orientation, shape, and movement in the signing space. Temporal phonological features such as prosody and rhythm are also known to play a crucial role in most sign languages, adding layers of meaning and aiding in the conveyance of complex ideas and emotions. Cross-lingual variation has also been studied. For example, Tang et al. (2010) found that while eye blinks were used to mark certain intonational phrases in Japanese Sign Language (JSL), HKSL, Swiss German Sign Language (DSGS), and ASL, their use in JSL was unique out of these languages for blinks co-occurring with head nods rather than sign lengthening.

Non-lexical expressions Non-lexical expressions in sign languages encompass a range of communicative behaviors beyond the use of lexical signs, and include non-manual expressions (Valli and Lucas, 2000; Sandler and Lillo-Martin, 2006), depicting signs (Liddell, 2003; Cormier et al., 2012), and even gestures (Liddell and Metzger, 1998; Goldin-Meadow and Brentari, 2017). Non-manual expressions involve the use of facial expressions, body posture, and eye movements to convey meaning, mood, or grammatical information, adding

depth and nuance to the signed message. Depicting signs use handshapes and movements to represent objects, actions, or concepts, often providing visual and spatial information about the subject matter. Gestures, although not strictly part of the formal sign language lexicon, are incorporated into communication, offering a universal means of conveying ideas or emotions, sometimes transcending linguistic boundaries. Together, these elements enrich the expressive capacity of sign languages, allowing for a dynamic and multifaceted mode of communication.

3. Sign Language Research Topics

We examined research topics in sign language studies that applied deep learning and selected several representative topics, as can be seen in Figure 1. We also identified research topics with relatively few or no publications, despite being important linguistic aspects of sign language.

3.1. Research Trends

We analyzed trends in sign language research from the past decade by reviewing a total of 544 papers from workshops, conferences, and journals in the fields of sign language, natural language processing, and computer vision. These papers were collected from the top twenty (by h5-index) publications in each of the following Google Scholar subcategories: Artificial Intelligence, Computational Linguistics, and Computer Vision & Pattern Recognition, in addition to selected papers from sign language workshops. The collection was restricted to works published between 2014 and early 2024. We categorized each paper by main topic and sub topic based on our interpretation of each paper's main focus. We provide our collection of relevant papers and paper topics through the digital repository link: <https://doi.org/10.5281/zenodo.10948417>.

Recognition Sign language recognition (SLR) involves automatically identifying handshapes, non-manual markers, fingerspellings, and glosses in video data and has seen the most active research (about 33% or 180 of 544 papers). Continuous and isolated SLRs are being advanced not only through improved feature extraction (He et al., 2016; Carreira and Zisserman, 2017; Xie et al., 2018) but also through new methods and applications such as better fusion of multiple input modalities (Chen et al., 2022), cross-frame feature trajectory analysis (Hu et al., 2023b), and knowledge distillation (Guo et al., 2023). Recently, sign spotting (Varol et al., 2022; Vázquez Enríquez et al., 2022) and sign segmentation (Woll et al., 2022; Moryossef et al., 2023) have

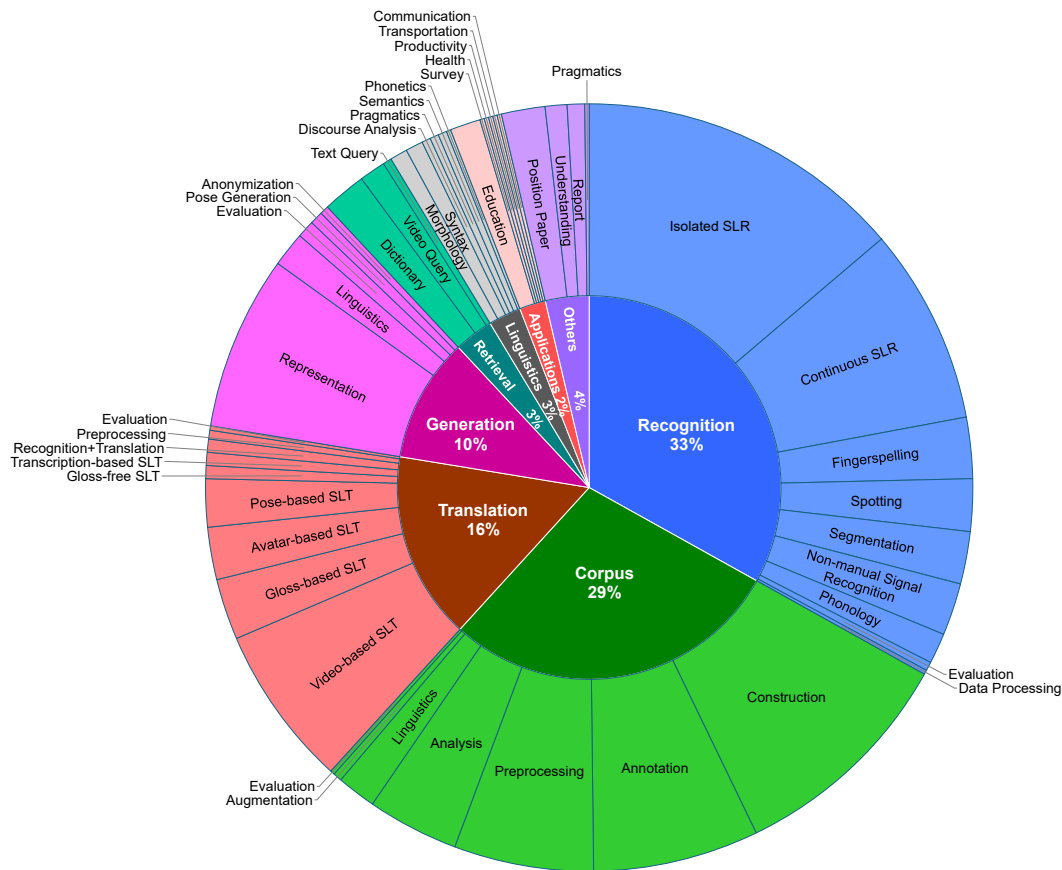


Figure 1: Research topics in sign languages. Tools for corpus, such as annotation and preprocessing, are included in each sub-topic depending on the purpose of the research.

emerged as prominent sub-topics.

Translation Sign language translation (SLT) is a task that translates between spoken language and sign language, or vice versa. Spoken language is represented through sound or text, and sign language is represented through gloss, skeletal pose, video (photo-realistic or avatar animation), or a notation system (usually SignWriting (Sutton, 2000) or HamNoSys (Hanke, 2004)). Recently, Gloss-free SLT, which translates sign language without the need for gloss supervision, has been actively researched (Yin et al., 2023; Lin et al., 2023; Zhou et al., 2023).

Generation Sign language generation (SLG) is the task of creating sign language poses or videos without translation¹. Research has been conducted on a variety of topics, including the diversity of expressions (Kopf et al., 2023) and the anonymization of sign language users (Saunders et al., 2021; Xia et al., 2022). There have also been active propos-

¹In this paper, we classify approaches that include both translation and generation as SLT and approaches that involve only sign language generation as SLG.

als for research aimed at reflecting sign language linguistics in the generation process (McDonald et al., 2014).

Retrieval While research on sign language dictionaries supporting word-based or handshape-based search has been active for some time, recent studies have focused on information retrieval through natural language queries in text (Duarte et al., 2022; Cheng et al., 2023) or video data (Sedmidubsky et al., 2018; De Coster and Dambre, 2023).

Understanding Although less researched than the other main topics, sign language understanding (SLU) has been explored in several ways. Recent studies have proposed methods for linguistically modeling sign languages (Mocialov et al., 2018; Hu et al., 2023a). An interesting development is the proposal of research on coreference resolution (Yin et al., 2021a) and a call to recognize SLU as a field within natural language processing (Yin et al., 2021b).

Others Sign language corpora have been crucial linguistic assets in sign language research for

an extended period, and corpora construction and analysis are areas that have received much focus. Additionally, applications and analysis of sign language in diverse areas such as health care, education, and communication have been proposed in academic papers. However, this paper focuses on deep learning-related research and does not extensively discuss these topics.

3.2. Underexplored Topics

Research in SLR, SLT, and SLG has advanced significantly, and yet some linguistic aspects of sign language modeling remain underexplored. This gap highlights a potential disconnect between research-generated output and actual signers' usage, underscoring the importance of incorporating sign language linguistics into future studies to ensure their authenticity and relevance. Below, we have listed research areas that, while being linguistically important in sign language, we believe are not being sufficiently researched.

Elicitation methodologies While elicitation methodologies have been studied extensively in traditional sign language corpora research and for spoken-language machine translation corpora, it has been mostly ignored in phrase-level sign language machine translation corpora, with few exceptions. [Matthes et al. \(2012\)](#) detailed how they developed tasks for capturing high-quality sign language utterances while still ensuring high overlap between multiple sign languages. [Huerta-Enochian et al. \(2022\)](#) compared several text-to-sign translation elicitation and revision methodologies and showed that text-based elicitation produced the least natural signing. Furthermore, we know that testing translation performance with back-translated data as the source language for spoken languages artificially inflates scores ([Zhang and Toral, 2019](#); [Graham et al., 2020](#)), but bias in development methodologies have not yet been explored for SLT.

Pragmatics in SLT SLT has now reached a level of maturity where it is poised to explore practicality in addition to novelty. To enhance the practical use of SLT, it is necessary to contemplate how to deliver sign language expressions from a pragmatic perspective. For instance, when translating and generating sign language, space should be used in concert with non-manual signals in order to generate easily-understandable translations. Recognition systems should be designed to handle a wide range of signs and integrate naturally with users without needing special gloves, cameras, or lights. Recently, [Fried et al. \(2023\)](#) called for increased focus on pragmatics for large language models

(LLMs), emphasizing the need for LLMs to adapt to the interlocutor. We suggest that this need is even greater for sign language modeling, given the crucial role of context in shaping how concepts are expressed.

Depicting signs Depicting signs are an area of research that is less frequently addressed in studies on SLR, SLT, and SLG. However, it is necessary to model depicting signs in each of these areas in order to approach the sign language representations actually used by signers. Since depicting signs are non-lexical expressions their use varies from person to person. There are many types of depicting signs, including the creation of gestures, the use of sign language to represent entities, and the description of situations through actions. Recent research on multi-modal large language models suggests new possibilities for exploring depicting signs. An important aspect of this research could be the representation of actions and relationships using one or both hands in sign language.

Rhythm and tension When generating sign language, the rhythm and stress of the signs are crucial elements in determining nuances. Similar to pragmatics, creating the appropriate sign language rhythm and stress according to the context will enable more natural sign language expressions and improve reception from the Deaf community.

Others There is a need for research on aspects that can be effectively used in sign language communication, such as topicalization and role-shifting. Moreover, translation between different sign languages could also present an intriguing area of study, potentially requiring methodologies distinct from those used in conventional translation. It is essential for research to more actively incorporate the history, culture, and linguistic aspects of sign language. There are also other areas in need of exploration, and we hope to see more proactive investigation of them in the future.

4. Challenges and Issues

We retrospectively examined existing studies with a focus on corpus and methodology challenges and explored how to resolve the issues identified.

4.1. Corpora

We examined a range of sign language corpora and summarized twenty-two commonly used corpora in [Table 1](#). Here we argue that the following considerations should be taken into account in the use, management, and further construction of sign language corpora.

Corpus	Language	Access	Video	Size	Channel	License
ASLG-PC12 (Othman and Jemni, 2012)	ASL	open	N	77M (24M)	single	CC BY-NC 4.0
ATIS (Bungeroth et al., 2008)	multilingual (DGS,ISL,SASL)	restricted	Y	595 (-)	multi	CC BY-NC 4.0
AUSLAN (Johnston, 2009)	Auslan	restricted	Y	- (-)	multi	CC BY-NC-ND 4.0
BSL Corpus (Schembri et al., 2017)	BSL	open(partial) / academic	Y	- (14,754)	multi	custom
BOBSL (Albanie et al., 2021)	BSL	restricted	Y	1.2M (-)	multi	custom
CONTENT4ALL (SWISSTXT-WEATHER) (Camgöz et al., 2021)	DSGS	restricted	Y	811 (-)	single	CC BY-NC-SA 4.0
CONTENT4ALL (SWISSTXT-NEWS) (Camgöz et al., 2021)	DSGS	restricted	Y	6,031 (-)	single	CC BY-NC-SA 4.0
CONTENT4ALL (VRT-NEWS) (Camgöz et al., 2021)	VGT	restricted	Y	7,174 (-)	single	CC BY-NC-SA 4.0
Corpus NGT (Crasborn and Zwitserlood, 2008)	NGT	open(partial) / restricted	Y	- (490)	multi	CC BY-NC-SA 4.0
CSL-Daily (Zhou et al., 2021)	CSL	academic	Y	20,654 (-)	single	custom
Dicta Sign (Matthes et al., 2012)	BSL, DGS GSL, LSF	academic / restricted	Y	- (-)	single	-
KETI (Ko et al., 2019)	KSL	restricted	Y	2,940 (-)	single	-
KRSL-OnlineSchool (Mukushev et al., 2022)	KRSL	restricted	Y	1M (-)	single	-
NCSLGR (Neidle and Vogler, 2012)	ASL	open	Y	1,887 (1,874)	multi	custom
NIASL2021 (Huerta-Enochian et al., 2022)	KSL	open(domestic)	Y	201,026 (180,892)	multi	custom
DGS Corpus (Konrad et al., 2020)	DGS	open(partial) / restricted	Y	- (63,922)	multi	custom
RWTH-BOSTON-104 (Dreuw et al., 2007)	ASL	open	Y	201 (201)	single	-
RWTH-PHOENIX-WEATHER-2014-T (Camgoz et al., 2018)	DGS	open	Y	8,257 (8,257)	single	CC BY-NC-SA 3.0
SignBank [◇]	multilingual	open	N	- (29,035)	multi	-
STS Corpus (Öqvist et al., 2020)	SSL	open(web-access) / registered	Y	- (-)	multi	CC By-NC-SA 4.0
RWTH-PHOENIX-WEATHER 2014 (Forster et al., 2014)	DGS	open	Y	6,861 (6,841)	single	CC BY-NC-SA 3.0
How2Sign (Cardoso Duarte et al., 2021)	ASL	open(w/o gloss)	Y	35,191 (-)	single	CC BY-NC 4.0

◇: <https://www.signbank.org/signpuddle/>, accessed on February 23, 2024

Table 1: Summary of reviewed corpora. We limited reporting to *sentence-level* data. **Access:** *open*, *registered* (available with registration), *academic* (available for non-commercial research or academia), and *restricted* (available only with explicit permission). We report multiple levels as applicable. **Size:** The reported sentence-level instance count and our calculated open access count, if available. Every effort was made to report correct sizes for open access data, but there may be some deviation based on access method. **Channel:** Data is categorized based on the presence of annotations for separate hands or for non-manual signals, regardless of the existence of multiple tiers. **License:** The current corpus license. Note that licenses may differ from those reported in original research or from software licenses.

Data format The central challenge to choosing a data annotation format is that sign representation fidelity is inversely related to representation simplicity. In other words, simple representations like glosses cannot adequately represent the nuances of multiple signed instances while more informative

representations like sign writing or even pose data are not easy to work with. This leads to variations in data and glossing formats across corpora, which in turn requires significant additional preprocessing before corpora can be used for training (De Sisto et al., 2022). Recently, there has been more inter-

est in rectifying this issue as can be seen in the proposed rectification of annotations from the easier project [Kopf et al. \(2022\)](#) and in [Schulder et al. \(2023\)](#) proposal of the sign language interchange format. While rectifying these differences between corpora is a good and necessary solution, using more unified annotation conventions for future corpus projects will be immensely helpful.

Data availability Though many corpora have been released for sign language research, collection and use of potential corpora is complicated by missing data links, mixed access levels, and custom licenses. Notably, some corpora were publicly available at the time of publication but are no longer accessible.

Commercial-friendly data Only two of the corpora we reviewed explicitly support commercial applications: the partially open release of the BSL Corpus and NIASL2021 (which is currently limited to users in Korea). In addition, five of the corpora do not include specific licensing information, introducing legal risks if used. The vast majority of corpora use derivatives of CC BY-NC or custom licenses that designate corpora for research purposes only. To encourage research from industry as well as academia, it may be necessary to reflect an incentive mechanism for data disclosure. However, in this case, ethical considerations such as re-obtaining consent from contributors due to a changing release policy and data anonymization should also be taken into account.

Signing quality Sign language corpora for machine learning show much variation in terms of signing quality. One major factor in this is the range of elicitation and collection methodologies. Some corpora feature only spontaneous utterances on open-ended topics, some corpora focus elicitation to specific tasks, and many corpora use either real-time interpretation or pre-translated utterances. We are not advocating against using specific corpora. On the contrary, given the small size of available data, utilizing existing corpora as much as possible—including corpora containing non-spontaneous signing—is necessary. While the effectiveness of high-quality training data is undisputed, lower-quality data is often utilized for pretraining, contrastive training, and other novel approaches. A key challenge moving forward will be to better classify signing data by recommended use and to improve elicitation techniques in general.

4.2. Methodologies

Text-to-sign translation There is a growing interest in direct pose- and video-predicting models, likely due to the lower annotation burden and the

appeal of end-to-end solutions. While visualization of single-channel gloss data is limited, it still has significant value for identifying bias, data balance issues, linguistic insights, for researchers invested in procedural generation, and in hybrid approaches. Similarly, high-cost annotations like multi-channel glosses and notation systems offer the possibility of higher fidelity translations in specific domains. While we agree that the potential of end-to-end solutions are the most promising in the long-term, we urge the community to keep prioritizing multiple data modalities given the continued need for both short-term and long-term solutions.

Modeling non-lexical signs Procedural generation of non-lexical signs from gloss annotations is extremely challenging. High-detail annotations like multi-channel glosses, AZee, HamNoSys, Sign-Writing, and other phonetic annotations provide additional possibilities for non-lexical sign generation. While end-to-end solutions should be able to produce non-lexical signs, hybrid approaches like the one explored by [Saunders et al. \(2022\)](#) are likely more realistic in the short-term.

Non-lexical sign recognition is also an area that may likely benefit from novel approaches, particularly by delving into the intricacies of sign language. Effective recognition of non-lexical signs may involve understanding sign language morphemes, identifying what entities the handshapes represent, or even interpreting the intent behind gestures. This deeper comprehension could lead to more effective communication aids for the deaf and hard of hearing, by not just recognizing signs as whole units but understanding their component parts and the meanings they convey in different contexts.

SLT automatic evaluation While traditional machine translation metrics (BLEU, Rouge, etc.) can be applied to simple gloss translations, there is no definitive metrics for the many other text→sign output representations. Recently applied and proposed metrics include SignBLEU ([Kim et al., 2024](#)) for multi-channel gloss prediction; BLEU, chrF2++, and mean absolute error metrics for Formal Sign-Writing ASCII ([Jiang et al., 2023](#)); and SLR pose classification accuracy ([Xiao et al., 2020](#)) and Fréchet Gesture Distance ([Yoon et al., 2020](#)) for pose prediction. As a community, we need to continue researching and improving potential metrics.

Human evaluation accessibility A hugely influential factor in the creation, evaluation, and curation of text-based data has been Amazon’s Mechanical Turk (MTurk). While MTurk can be used for sign language data, finding highly-specialized participants through MTurk is a known challenge ([Chandler and Shapiro, 2016](#)). Furthermore, due to

communication barriers and ethics board requirements, most human evaluation of sign language is conducted locally and limited to the local sign language. This means that most machine learning research is human-validated on a single sign language or none at all. We see the need for better international cooperation, preferably as an official network, devoted to ensuring high-quality human evaluation for sign language applications.

5. Possible Directions

In the previous section, we placed as much importance on the practicality of sign language research outcomes as on improving performance. Here, we provide insights into areas that we think should receive increased focus in future research.

Additional annotation of existing corpora We have observed that understanding the position and direction in sign language plays a crucial role in comprehending its syntax. Therefore, transcribing this information, either automatically or manually, and applying it to SLR, SLT, and SLG models is essential.

Elicitation methodologies In light of the data scarcity problem in SLR, SLT, and SLG, the quality of signing data is of increased importance, and there are several urgent research directions to be explored. Data for specific translation applications usually requires highly-structured translations from existing spoken-language text. However, improving the quality of text-to-sign translations while ensuring high content fidelity is an open problem. As mentioned in section 3, traditional corpora research suggests using language-neutral elicitation materials, but applying such media to translation of specific phrases needs more exploration. In order to avoid bias, we need to research proper methodologies for sign language translation train and test set construction.

Pragmatics Pragmatics in sign language explores how language functions within social contexts and interactions. To address this, a deep learning model methodology is essential—one that not only minimizes ambiguity but also ensures communication objectives are met through word choice, spatial utilization, and the use of non-manual expressions. Establishing a clear evaluation framework is equally crucial to assess a model's overall effectiveness in enhancing clarity and communication efficiency. [Fried et al. \(2023\)](#) proposed how to model pragmatics with large language models to achieve these communication goals for all natural languages.

Non-lexical signs Effective modeling of non-lexical signs will require novel solutions, and we expect that many potential solutions will be found in linguistic insights. For example, [Taub \(2001\)](#) first proposed the analogue-building model process which is comprised of three steps (image selection, schematization, and encoding), and subsequent studies ([Emmorey, 2014](#); [Nordheimer et al., 2024](#)) have built on and applied this model. We see the potential of this method applied to SLT through an approach using knowledge distillation and representation learning as a way to train entity translation in a generalizable way.

Hate speech The exploration of hate speech in sign language research is essential for the development of protective measures and educational tools that can help safeguard communities from discrimination and abuse. The nuanced gestures and expressions unique to sign languages can convey complex emotions and intentions, making it vital to understand how hate speech manifests in these modes of communication. Consequently, building comprehensive corpora that capture the breadth of sign language expressions, including those that could be considered hate speech, is imperative. These corpora will not only facilitate the identification and mitigation of hate speech within sign language communication but also contribute to the broader efforts of promoting digital safety and inclusiveness for all, regardless of mode of communication.

Deaf involvement Currently, Deaf involvement in sign language machine learning research is largely limited to participation in corpora construction and annotation and in human evaluation of developing technologies. Limited Deaf involvement in research means that hearing-centric views may grow unchecked and we risk losing sight of meaningful research objectives. On the other hand, increased involvement will provide insights to which non-native signers do not have access and ensure that we work towards developing solutions that the community can actually use.

6. Concluding Remarks

We have explored areas within sign language research that have not been well addressed. We also examined and proposed directions for future research in these areas. We argue that future sign language studies should be more closely connected with sign language linguistics and reconsider their practicality. We hope that by doing so, research outcomes will be more readily accepted in Deaf communities. Not all research topics could be covered in this paper, and as research progresses,

downstream tasks of NLP that are currently underexplored for sign language, including summarization, question answering, and language modeling, will likely receive more attention.

Acknowledgment

This work was partly supported by the Institute for Information and communications Technology Promotion (IITP) grant funded by the Korean government (MSIT) (No. 2022-0-00010, Development of Korean sign language translation service technology for the deaf in medical environment) and Artificial intelligence industrial convergence cluster development project funded by the Korean government (MSIT) & Gwangju Metropolitan City (No. BA00000797, LLM-based sign language translation for weather forecasts).

Sign Language Abbreviations

ASL American Sign Language
Auslan Australian Sign Language
BSL British Sign Language
CSL Chinese Sign Language
DGS German Sign Language
DSGS Swiss-German Sign Language
GSL Greek Sign Language
ISL Irish Sign Language
KRSL Kazakh–Russian Sign Language
KSL Korean Sign Language
LSF French Sign Language
NGT Dutch Sign Language
SASL South African Sign Language
SSL Swedish Sign Language
VGT Flemish Sign Language

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