

Comparative Analysis of Sign Language Interpreting Agents Perception: A Study of the Deaf

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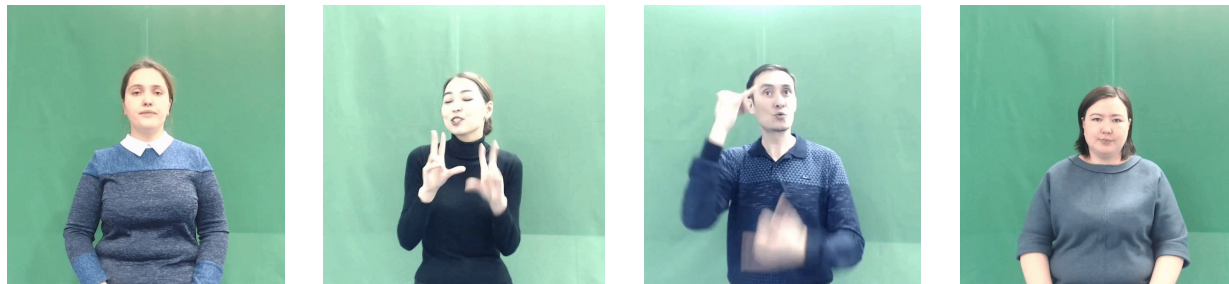
Importance of the field

- According to WHO report, there are 180 million deaf people [1]
- Contrary to popular belief, deaf people's literacy rate is very low as they can read and write but often do not fully understand the meaning.
- The education level of high school graduates is reported to be similar to fourth graders in the USA [2]
- Less access to higher education and as a result to a well-paid employment
- Experience Social isolation
- Need for inclusive internet

[1] World Health Organization (2018). Deafness and hearing loss. <http://www.who.int/mediacentre/factsheets/fs300/en/>. Accessed 21 Nov 2018

[2] Moreire, D. A. (2012). Measures of writing, math, and general academic knowledge. In *Assessing Literacy in Deaf Individuals* (pp. 127-137). Springer, New York, NY.

What is Sign Language?



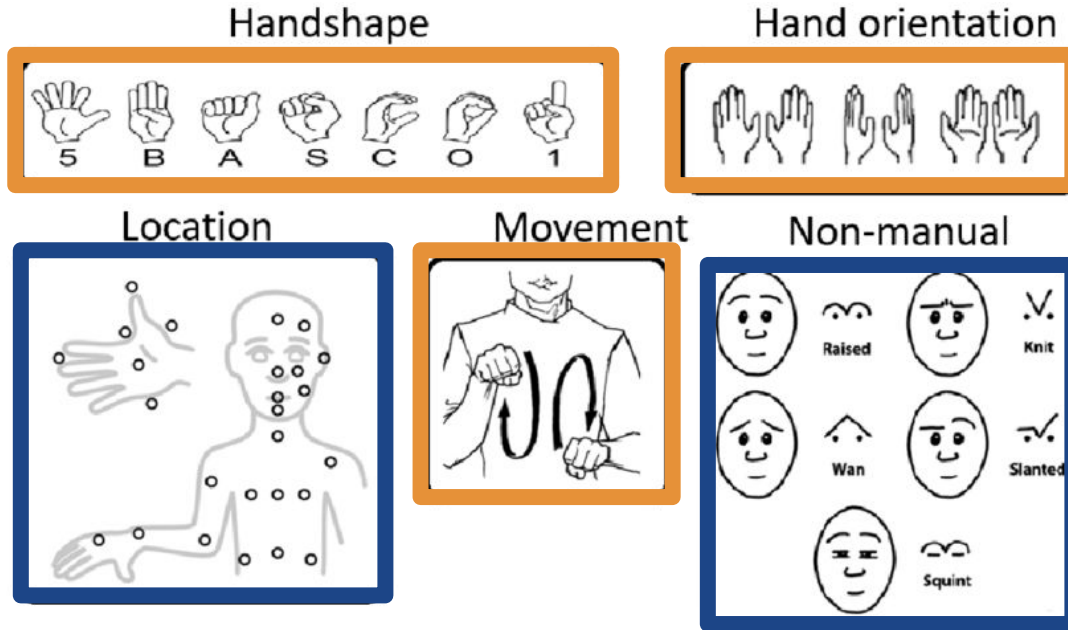
- SL is the first language of any deaf individual.
- Full-fledged natural language with their own grammar and lexicon.
- Expressed via the manual (hand configurations and positions) and non-manual elements (facial expressions).
- Each country or region has its own sign language.
- Over 300 sign languages used around the world, and 70 million deaf people using them [3]

Sign Language context in Kazakhstan

- About 200k deaf people live in Kazakhstan
- Not an indigenous language
- Based on the signing system developed in USSR
- Lack of proficient interpreters, high workload on each of them
- Own concepts (musical instruments, traditional culinary, renowned landmarks, notable personalities).



The five components of signs in sign languages

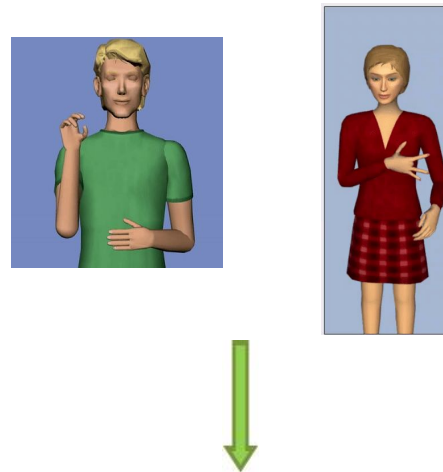


The five components of signs in sign languages

Motivation for Sign Language Generation

Demerits of previous Sign Language avatars:

- mostly hand-programmed and rule-based solutions
- time-consuming and expensive
- expert interpreters confirmation is always needed
- usually insufficient sign representation, limited vocabulary
- usually unnatural facial and robotic motions
- challenging to comprehend context



Why to shift for Intelligent Virtual Avatars (IVA) and

Intelligent Sign Language Generating Avatars (SLGA):

- data-driven methods allow to automatically animate signings
- closer to human-like degrees of freedom
- minimize time and cost



Objectives

- to compare the cutting edge technology with an actual human proficient interpreter
- to propose a methodology (experimental design, metrics, etc.) for evaluating human-agent interaction by deaf people

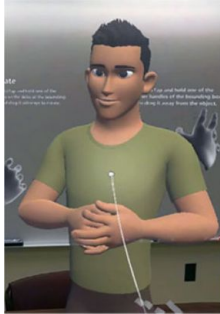
Also,

- to observe the perception of signing avatars by the representatives of local deaf community
- to figure out which additional elaboration/stimuli/items deaf people needed to simplify written questionnaires for deaf survey participants' needs

Related work



SigML[4]



MR classroom[5]



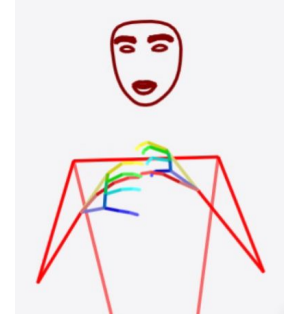
DGS, 2D to 3D[6]



aiSL-a[7]



BuHamad[8]



SignMT[9]

[4] <https://vh.cmp.uea.ac.uk/index.php/SigML>.

[5] Yang, F. C., Mousas, C., & Adamo, N. (2022). Holographic sign language avatar interpreter: A user interaction study in a mixed reality classroom. *Computer Animation and Virtual Worlds*, 33(3-4), e2082.

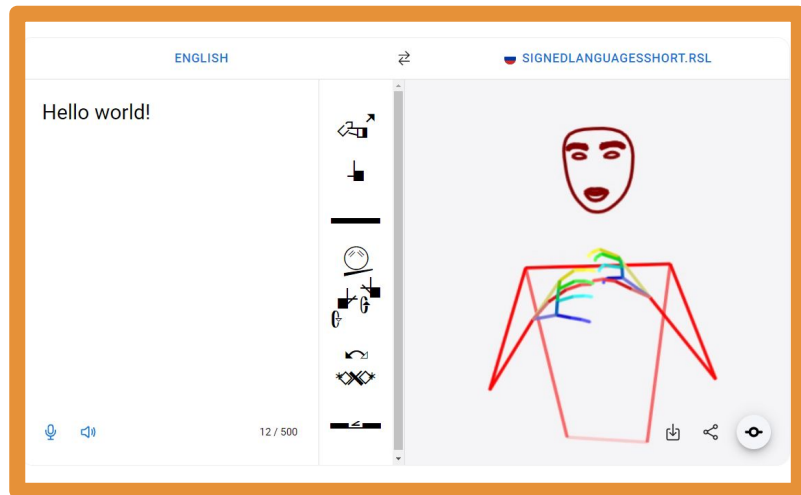
[6] Nguyen, L. T., Schickanz, F., Stankowski, A., & Avramidis, E. (2021, August). Automatic generation of a 3D sign language avatar on AR glasses given 2D videos of human signers. In *Proceedings of the 1st international workshop on automatic translation for signed and spoken languages (AT4SSL)* (pp. 71-81).

[7] Imashev, A., Oralbayeva, N., Kimmelman, V., & Sandygulova, A. (2022, December). A user-centered evaluation of the data-driven sign language avatar system: A pilot study. In *Proceedings of the 10th International Conference on Human-Agent Interaction* (pp. 194-202).

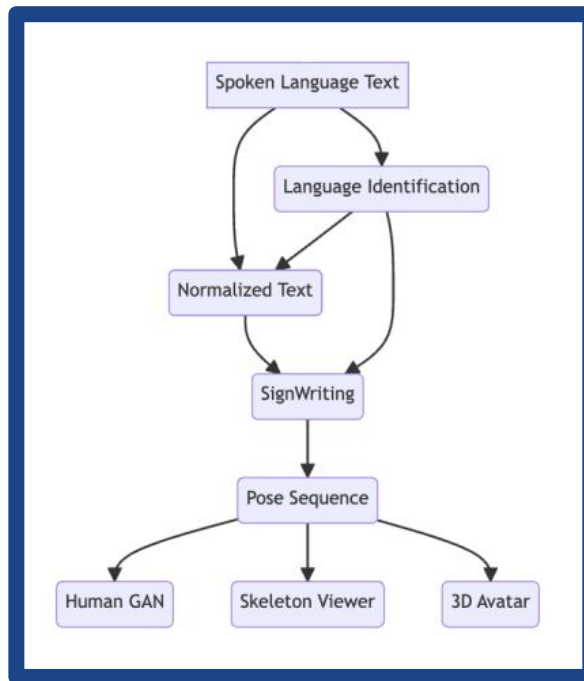
[8] El Ghoul, O., & Othman, A. (2022, March). Virtual reality for educating Sign Language using signing avatar: The future of creative learning for deaf students. In *2022 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1269-1274). IEEE.

[9] Moryossef, A. (2023). sign. mt: Real-Time Multilingual Sign Language Translation Application. *arXiv preprint arXiv:2310.05064*.

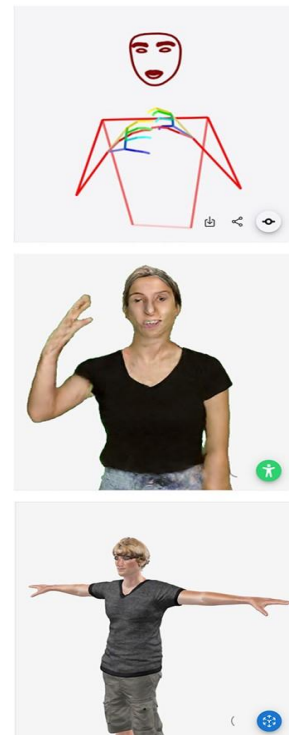
System design: Agent 1 (SignMT)



The interface of SignMT



SignMT approach pipeline



Output options

Agent 2 (Human interpreter)

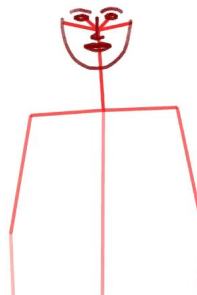


- A proficient interpreter local Kazakh-Russian sign language
- CODA (child of deaf adults)
- Familiar with local deaf culture
- Holds a bachelor's degree in defectology
- 7 years of professional experience as TV interpreter

Method:

- a within-subject design with 12 deaf participants,
- 2 agents involved: 1 avatar (SignMT stick-figure) and 1 human agent,
- 3 signing sequences per each avatar,
- translations by participants,
- Godspeed questionnaire metrics

Agent 1:
SignMT



Agent 2:
Proficient signer



Method:

Gender	Age	Education
M	31	9th grade
M	53	11th grade
F	36	College
F	27	College
M	36	Bachelor
F	33	College
F	34	College
M	44	9th grade
F	44	9th grade
M	37	11th grade
F	28	9th grade
M	33	11th grade

Demographics

Stick Figure Agent (SignMT)

1. BIG AND GREY ELEPHANT
 2. I AFRAID WOLF
 3. BEAR EAT BERRIES
-

Human interpreter

1. YOU WATCH YOUTUBE
 2. WEATHER TODAY WET
 3. WHICH YOUR FAVOURITE MOVIE
-

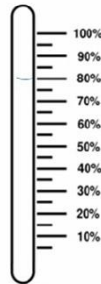
Stimuli: signing sentences performed by agents

Method:

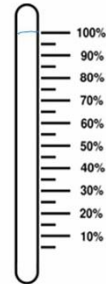
Section	Items	
Anthropomorphism	Fake	- Natural
	Machinelike	- Humanlike
	Unconscious	- Conscious
	Artificial	- Lifelike
	Moving rigidly	- Moving elegant
Animacy	Dead	- Alive
	Stagnant	- Lively
	Mechanical	- Organic
	Artificial	- Lifelike
	Inert	- Interactive
Likeability	Apathetic	- Responsive
	Dislike	- Like
	Unfriendly	- Friendly
	Unkind	- Kind
	Unpleasant	- Pleasant
Perceived Intelligence	Awful	- Nice
	Incompetent	- Competent
	Ignorant	- Knowledgeable
	Irresponsible	- Responsible
	Unintelligent	- Intelligent
	Foolish	- Sensible

VS.

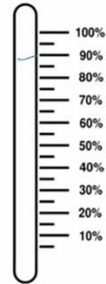
Inert - Interactive



Dead - Alive



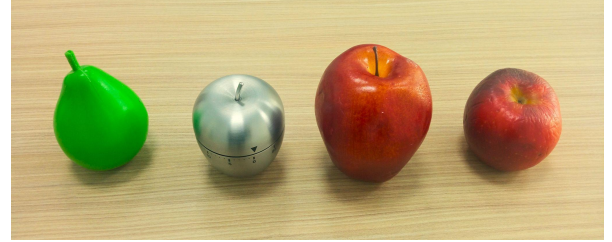
Ignorant - Knowledgeable



“Classic” Godspeed questionnaire [10] (1 -5 range)

Proposed questionnaire scales

Method:



Results (comprehension):

- The Wilcoxon Signed-Rank test revealed a statistically significant difference between the comprehension of the SignMT and Human agent: **$Z= 2.6, p=.009$** .
- The Shapiro-Wilk test did not indicate a significant departure from normality for the SignMT, but did indicate a significant departure from normality for the Human agent.

Agent	Mean (SD)	Shapiro-Wilk test
SignMT	37.59 (15.61)	$W = 0.897, p = 0.243$
Human	98.78 (3.67)	$W = 0.39, p < .001$

Results (Godspeed adapted proposed scale):

Section	SignMT	Human
Anthropomorphism	18.00(12.76)	96.25(4.67)
Animacy	20.49(12.09)	93.26(7.27)
Likeability	40.50 (22.61)	91.17(11.57)
Intelligence	30.13(20.13)	91.00(12.28)

Mean values and standard deviations of evaluation by the proposed scale

- The Shapiro-Wilk test did not indicate a significant departure from normality for SignMT across all sections
- The the Shapiro-Wilk test revealed a significant departure from normality in the Human Agent for all sections

Section	Shapiro-Wilk test
Anthropomorphism	$W = 0.924; p = 0.322$
Animacy	$W = 0.970; p = 0.918$
Likeability	$W = 0.947; p = 0.595$
Intelligence	$W = 0.945; p = 0.561$

Shapiro-Wilk test outputs for all sections: SignMT

Section	Shapiro-Wilk test
Anthropomorphism	$W = 0.819, p = 0.016$
Animacy	$W = 0.822, p = 0.017$
Likeability	$W = 0.749, p = 0.003$
Intelligence	$W = 0.750, p = 0.003$

Shapiro-Wilk test outputs for all sections: Human interpreter

Results:

- The Wilcoxon Signed-Rank test demonstrated a statistically significant difference in participants' perception between SignMT and Human-agent for all questionnaire sections

Section	Wilcoxon Signed-Rank test
Anthropomorphism	$Z = 3, p = .002$
Animacy	$Z = 3, p = .003$
Likeability	$Z = 3.4871, p < .001$
Intelligence	$Z = 3, p = .003$

Findings:

- Interpreters' additional elaborations were not enough fully enough again, vivid artifacts needed not only on an inquiry scale edges, but also in between.
- SignMT stick figure agent facials (mouthings and emotions were not always comprehensible)
- Thumbs of SignMT stick figure agent are too long, different colors of fingers mix up during signings
- Thermometer scale may offer a broader range for more specific subjective evaluation

Discussion:

- One deaf interpreter is also needed along with interpreters to explain the meanings.
- Larger number of participants to be involved.
- It is advisable to use more agents for comparison.
- To compare sorting tasks with the proposed scale and standard Likert scale for all questionnaire.
- Longer sign sentences needed to perform: short stories, tales, historical essays, etc.
- A new section named "Perceived SL Proficiency" to the questionnaire is needed.

Thank you for your attention!
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