Recognizing highly variable American Sign Language in virtual reality

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Signing Avatars& Immersive Learning

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Introduction

- Over 5% (430 million) of the world's population has some form of hearing loss, which is projected to increase to 2.5 billion by 2050[1].
- American Sign Language (ASL) recognition in 2D/3D is a relatively mature research area than virtual reality (VR).
- As immersive technology grows, ASL interactions in VR are more relevant and timely.

1. https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss

Objectives

- The objectives of this research are to teach ASL in VR and make the learning process fun and entertaining [2,3].
- State-of-the-art ASL recognition research mostly focused on 2D or RGB-D-based cameras where users cannot feel the real-world 3D experience. Our focus is to develop more interactive learning environment.
- Provide real-time feedback to the users.

2. Quandt, L. C., Lamberton, J., Leannah, C., Willis, A., & Malzkuhn, M. (2022). Signing avatars in a new dimension: Challenges and opportunities in virtual reality. In *Proceedings of the 7th International Workshop on Sign Language Translation and Avatar Technology (SLTAT)*

3. Quandt, L. C., Lamberton, J., Willis, A. S., Wang, J., Weeks, K., Kubicek, E., & Malzkuhn, M. (2020). Teaching ASL signs using signing avatars and immersive learning in virtual reality. In *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '20), October 26–28, Virtual Event, Greece*.

Concept

- Interactive learning system in VR
- Student
  - User of the system (ASL learner).
  - Will get feedback from the system about sign accuracy.
- Teacher
  - Animated avatar who teaches ASL.
  - Mocap data from a native signer.
  - “Decides” whether the student's sign is correct or not.

Student

Teacher

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Signing avatars in a 3D environment

- We designed a 3D interactive coffee shop environment
- The avatar acts as the Teacher and shows ASL signs
- A motion capture system (Vicon) was used to animate the 3D avatar
- We have nine different coffee shop sign in our sign vocabulary

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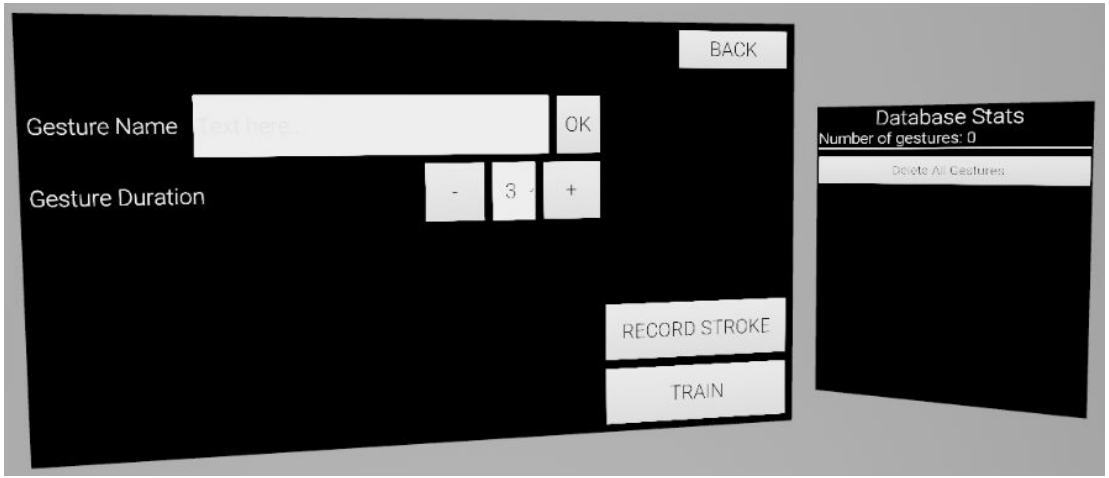
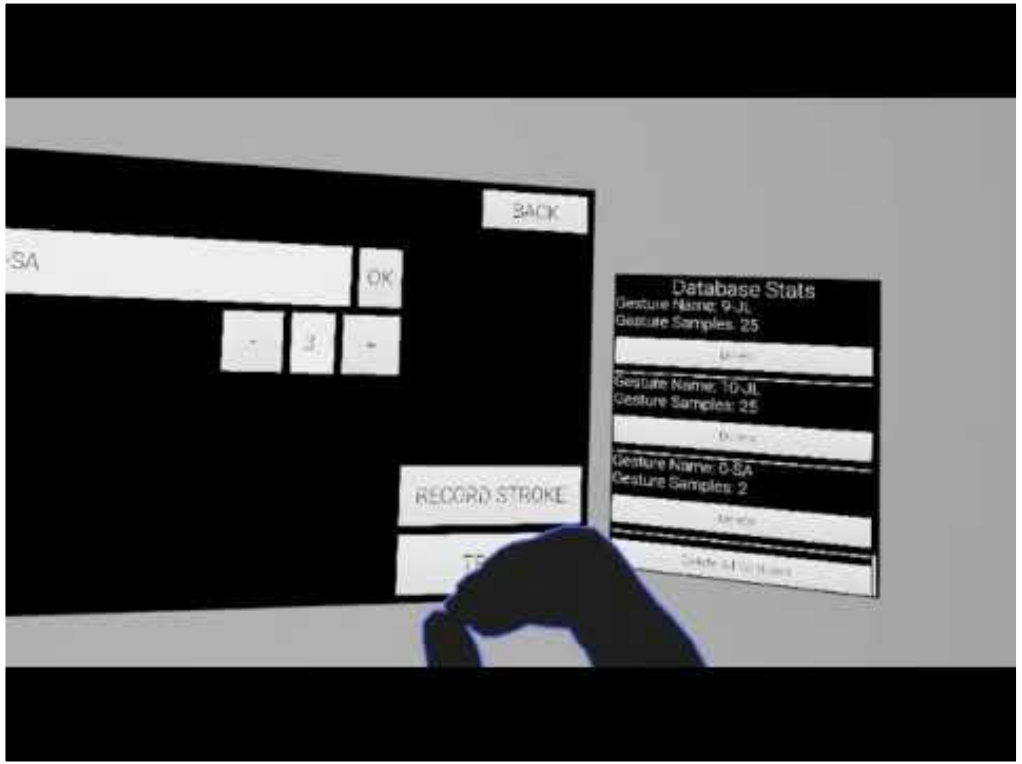
Data Collection

- Data plays an important role in any machine learning and deep learning research.
- For the training process, we gathered ASL sign data from native signers.
- A user interface (UI) was designed where users could interact with some basic buttons and record ASL signs without much external intervention.
- User can see the existing and new sign in the right window (see next slide).



Data Collection - Video



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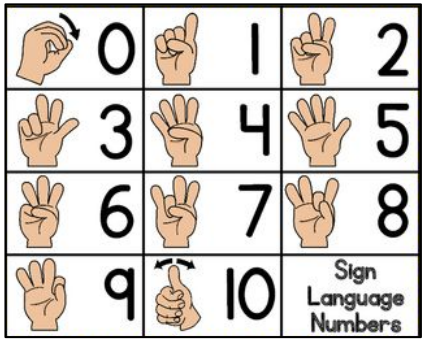
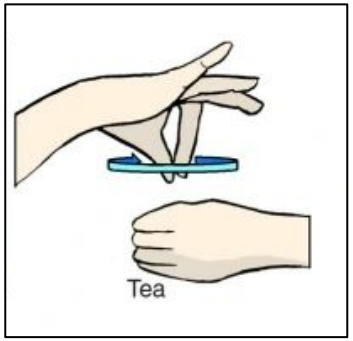
Datasets

- We trained two different models with different dataset-
  - ASL numbers 0-10
  - TEA sign

ASL Number sign



ASL TEA sign



Number Signs 0-10

- Total signs: 2500
- Participants: 10
  - Men: 4
  - Women: 6
  - Age range: 22-46
- Hearing status: D, H, HH

TEA Sign

- Total signs: 500
- Participants: 10
  - Men: 4
  - Women: 6
  - Age range: 22-46
- Hearing status: D, H, HH

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Experimental Setup

- VR Device: Oculus Quest 2 (software version 44.0.0.169.455).
- Environment: Unreal Engine v4.27
- AI Plugin: MiVRy v2.5
- PC:
  - Windows 11 pro 64 bit
  - Memory: 32GB
  - Processor: Core i9 3.50Ghz

Methods

- Sign recognition is performed by an AI model.
- MiVRy Unreal Engine plugin is used for sign recognition.
- The AI model is generated based on training data.
- The model provides similarity values in real time and this is the backbone of our feedback system.

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Results

- Each number was signed 10 times.
- Average accuracy was 46%.
- Best and worst result found for numbers 10 and 6, respectively.

*The recognition accuracy of the sign TEA is around 55%.

The model guesses (recognizes) this:

The signer signs this:

	0	1	2	3	4	5	6	7	8	9	10
0	4	1	0	0	0	0	0	0	0	0	3
1	1	7	0	0	0	0	0	0	0	0	2
2	0	3	3	0	0	0	0	0	0	0	4
3	0	0	4	3	0	0	0	0	0	0	3
4	0	0	0	0	4	3	0	0	0	0	3
5	0	0	0	0	3	6	0	0	0	0	1
6	0	0	0	7	0	0	2	0	0	0	1
7	1	0	5	0	0	0	0	3	0	0	1
8	0	4	0	0	0	0	0	0	3	0	2
9	4	1	0	0	0	1	0	0	0	3	1
10	2	0	0	0	0	0	0	0	0	0	8

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Conclusion

The ten signers in this initial study were *diverse* in age, sex, ASL proficiency, and hearing status, with most being deaf lifelong ASL users.

Next steps:

- Improve our recognition accuracy by modifying the AI model
- Add more content / signs
- Continue building the 3D environments
- Continue adding rich facial expressions to the avatars

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Thank you! Questions?

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