AI for Signed Languages: Challenges and Opportunities

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Berkeley NLP

Berkeley AI Research

Outline

1. Quick intro to signed languages

2. Current AI progress and challenges

3. Our work: ASL STEM Wiki (dataset and model to support deaf STEM education)

4. Exciting future directions

Nice to meet you! (ASL)

Common misconceptions of signed languages

❌ It’s just gestures for spoken language

❌ It’s just hand gestures

❌ There’s only 1 universal sign language

❌ It’s slower than speaking

“Name”

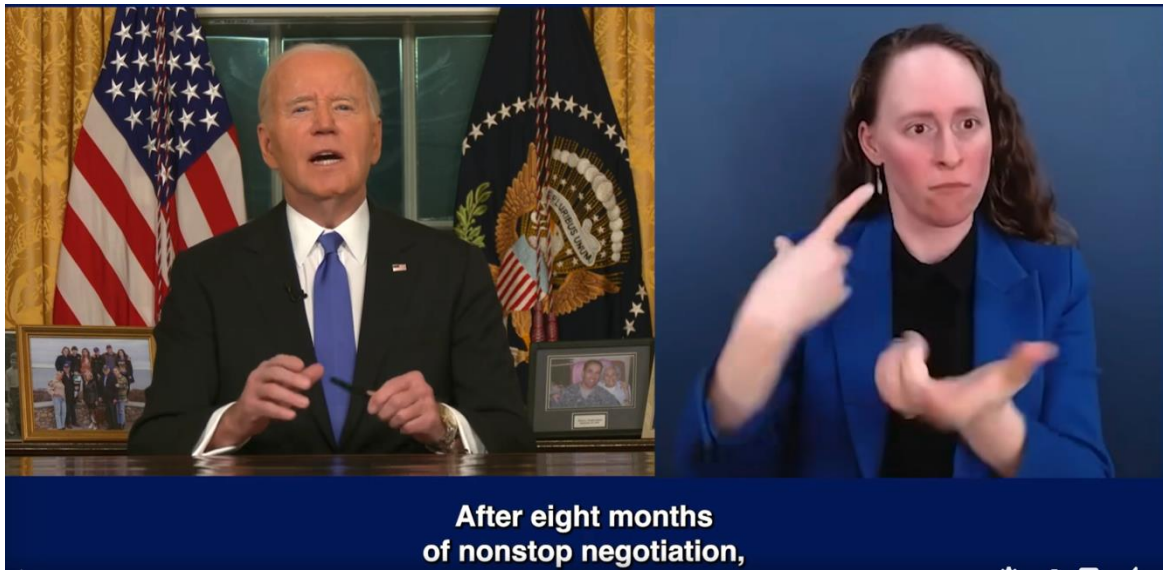
American Sign Language

British Sign Language

Signed languages are crucial

- Only 30-40% of English speech can be lipread
- Cochlear implants do not provide complete access to spoken language
- Integral to Deaf culture

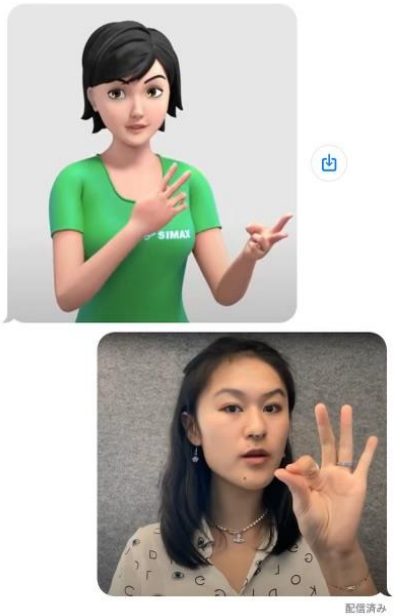
Why not just use subtitles / text?



- Convey tone, emotion
- Literacy levels vary among signers
- Primary / most accessible language for many

Possible applications of AI

Translation



Chatbots

Smart assistants

Education

Information retrieval

Current progress in AI for signed languages

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- 101 papers between 2021-2023 (Desai et al., 2024)

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SignLLM
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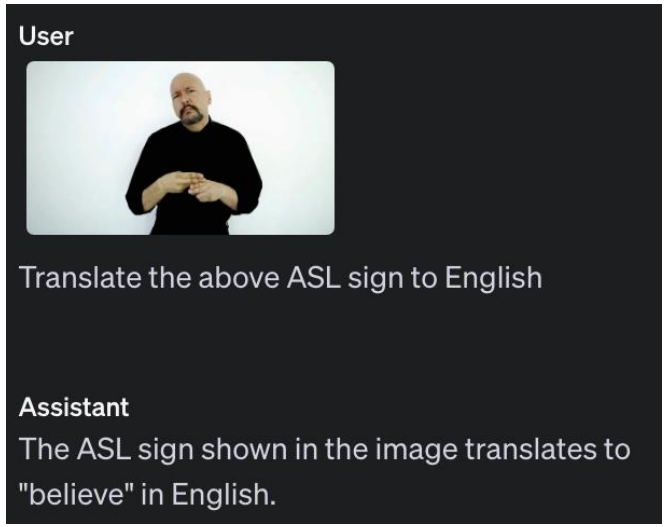

GPT-4o
(OpenAI, 2024)

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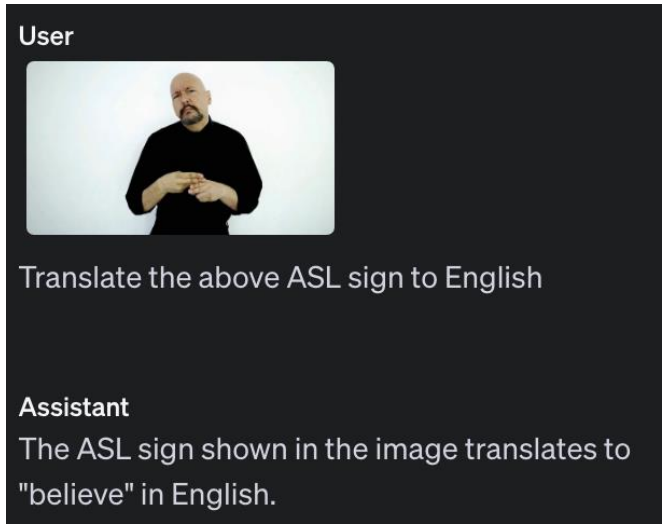


GPT-4o
(OpenAI, 2024)

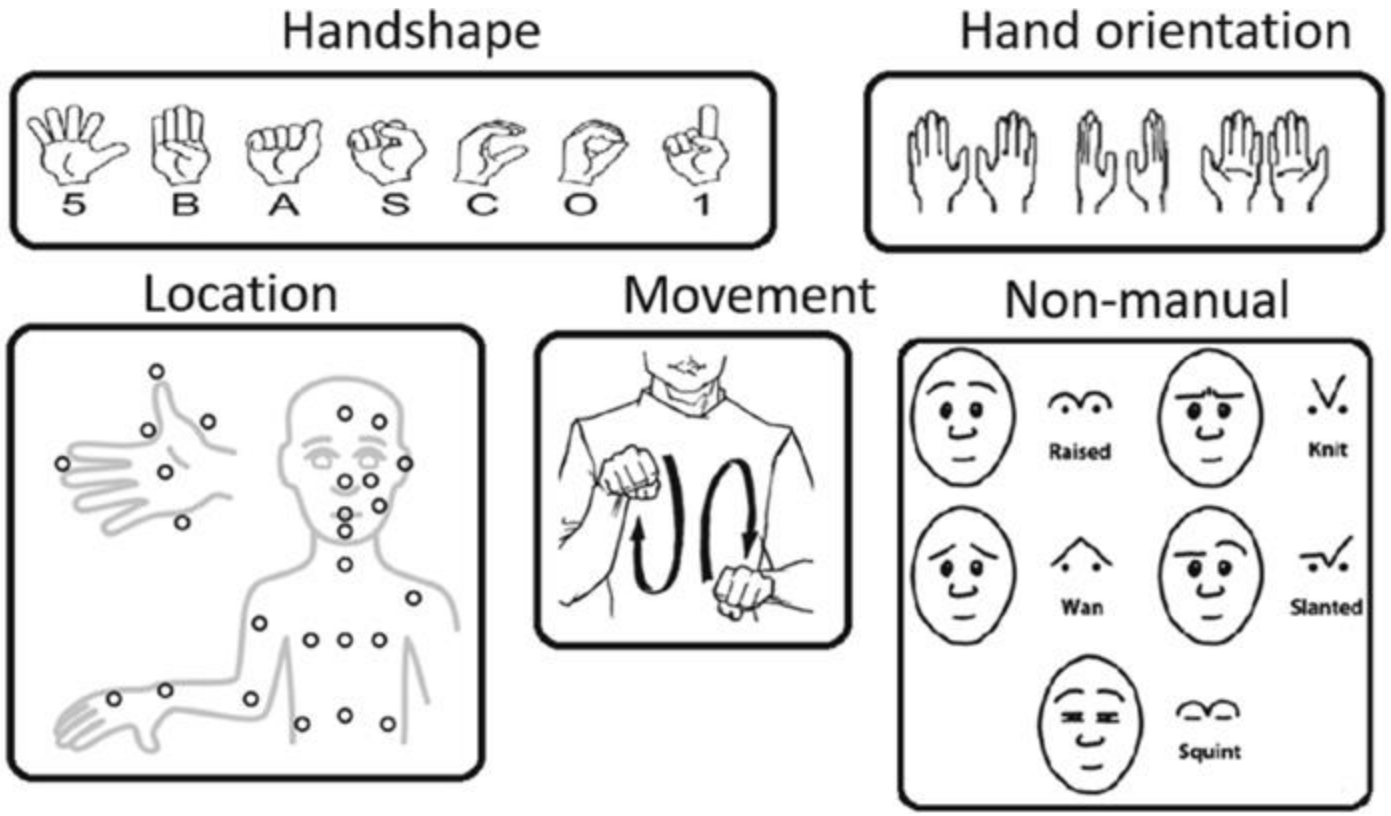
“Sign language gloves”

Challenge: data

- ~ 40 public datasets
  - Largest: ~1000 hours
- Gap between training data and target users
- 1 min of annotated data = 600 hours of collection
- Consent and privacy?

BOBSL dataset
(Albanie et al., 2021)

Challenge: simultaneous channels



5 phonological parameters of ASL

- Hands, face, body all express meaning
- Subtle, fine-grained visual signal
- Continuous, complex video modality

Challenge: spatial dependencies

Directional verbs in ASL

- Space expresses grammar, relationships, storytelling
- Pointing, eye gaze, head tilt, body shift, hand path

- Long spatial context
- Intentional vs. random motion?

Challenge: Deaf-centric design

April 12, 2016

UW undergraduate team wins $10,000 Lemelson-MIT Student Prize for gloves that translate sign language

Wearable-tech glove translates sign language into speech in real time

The device is inexpensive, flexible and highly durable, UCLA bioengineers say

Matthew Chin
June 29, 2020

Hand-ear co-ordination: Interactive glove translates sign language into speech

Infinity Glove, a Lebanon-based start-up, seeks to help translate sign-language into speech by using a high tech glove solution. Cody Combs / The National

Cody Combs
Feb 21, 2024

Listen In English Listen in Ar

Powered by automated trans

Challenge: Deaf-centric design

Why Sign-Language Gloves Don't Help Deaf People

Wearable technologies that claim to translate ASL overlook the intricacies of the language, as well as the needs of signers.

By Michael Erard

Sign Language Translating Devices Are Cool. But Are They Useful?

Emily Matchar

Innovation Correspondent

February 26, 2019

News & Views | Published: 15 July 2020

WEARABLE TECHNOLOGY

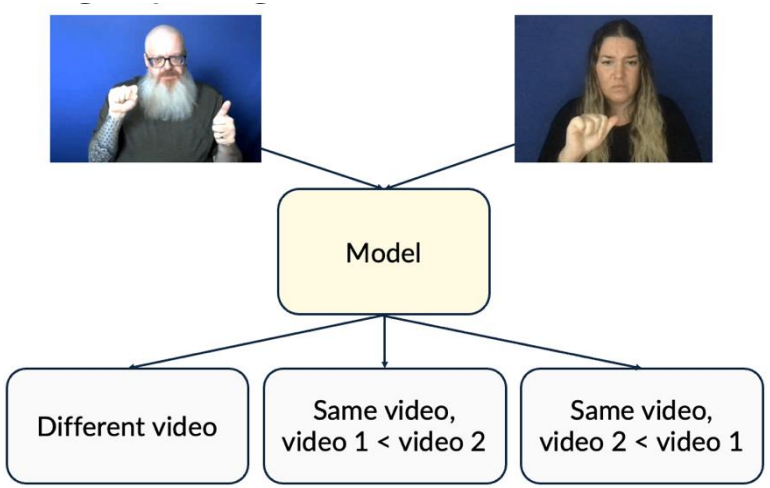
Do deaf communities actually want sign language gloves?

Joseph Hill

Addressing these challenges: ASL STEM Wiki

Dataset to support
DHH students in STEM

Addressing these challenges: ASL STEM Wiki

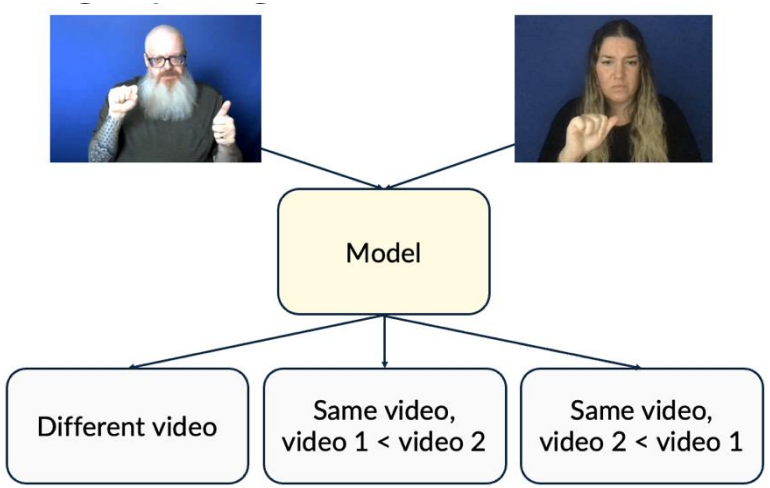


Dataset to support DHH students in STEM

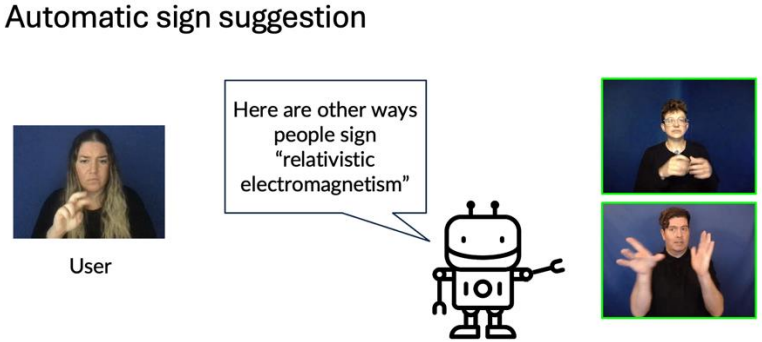
Self-supervised sign language modeling

Addressing these challenges: ASL STEM Wiki

Dataset to support DHH students in STEM



Self-supervised sign language modeling



Tool to assist ASL interpreters

ASL STEM Wiki

Dataset and Benchmark for Interpreting STEM Articles

Kayo Yin, Chinmay Singh, Fyodor O. Minakov, Vanessa Milan

Hal Daumé III, Cyril Zhang, Alex X. Lu, Danielle Bragg

Barriers to STEM education for DHH students

- ASL -> primary and most accessible language for many deaf and hard-of-hearing (DHH) students in the US

“Relativistic electromagnetism”

Barriers to STEM education for DHH students

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  - Deaf students score higher on science with direct instruction in ASL (Kurz et al., 2015)

“Relativistic electromagnetism”

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- STEM resources in ASL are **scarce**

“Relativistic electromagnetism”

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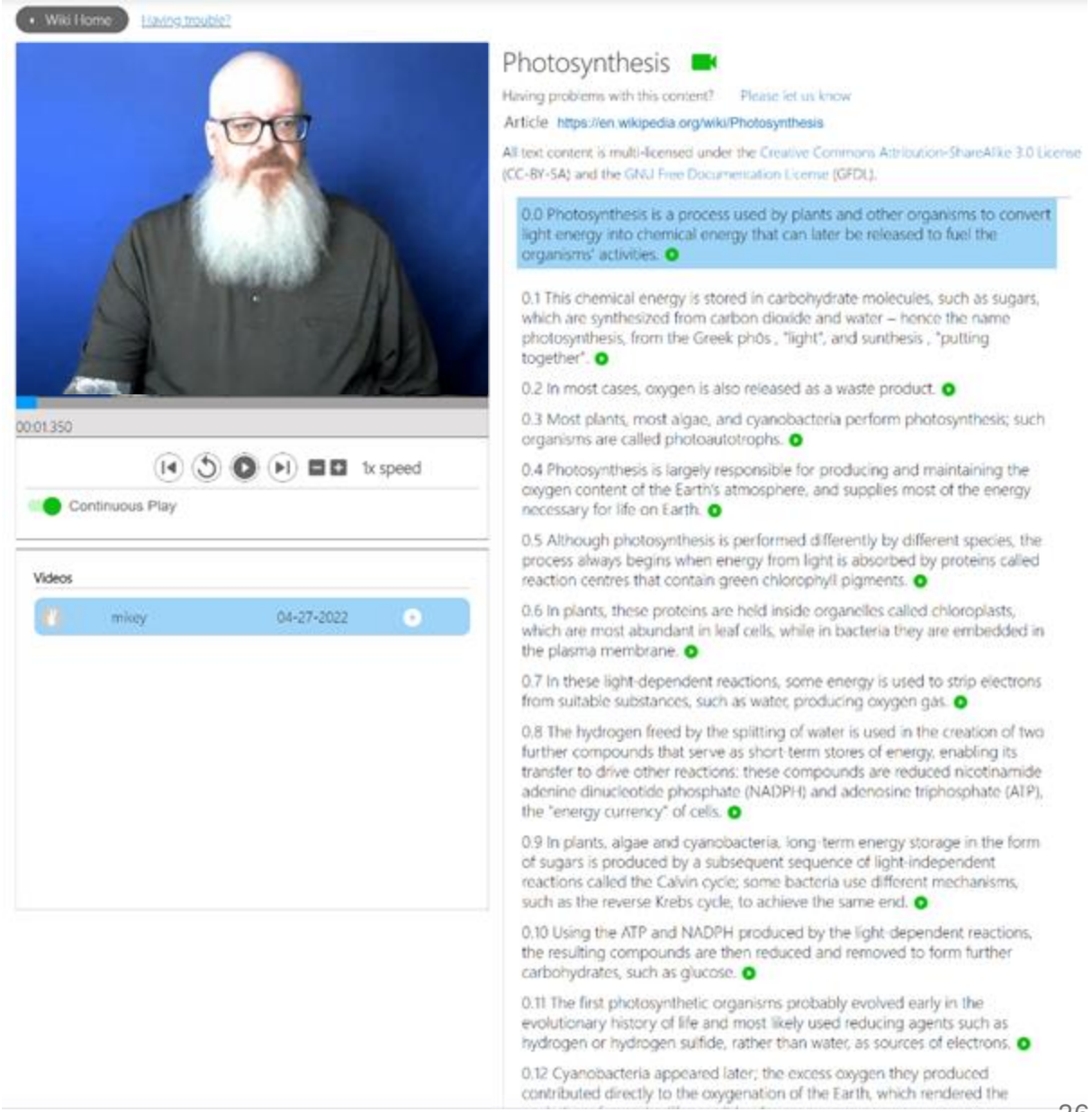
- STEM resources in ASL are **scarce**
- Lack of **standardized ASL signs** for technical words

“Relativistic electromagnetism”

ASL STEM Wiki

- 254 Wikipedia articles
  - Science, technology, mathematics, medicine, geography
- 300+ hours
- 37 certified ASL interpreters



Contributions

1. First dataset of continuous signing for STEM: **ASL STEM Wiki**
2. Linguistic analysis & appropriate use cases
3. New AI tool: **automatic sign suggestion**
4. New modeling technique: **contrastive learning** for signed language

Linguistic analysis – fingerspelling in ASL STEM Wiki

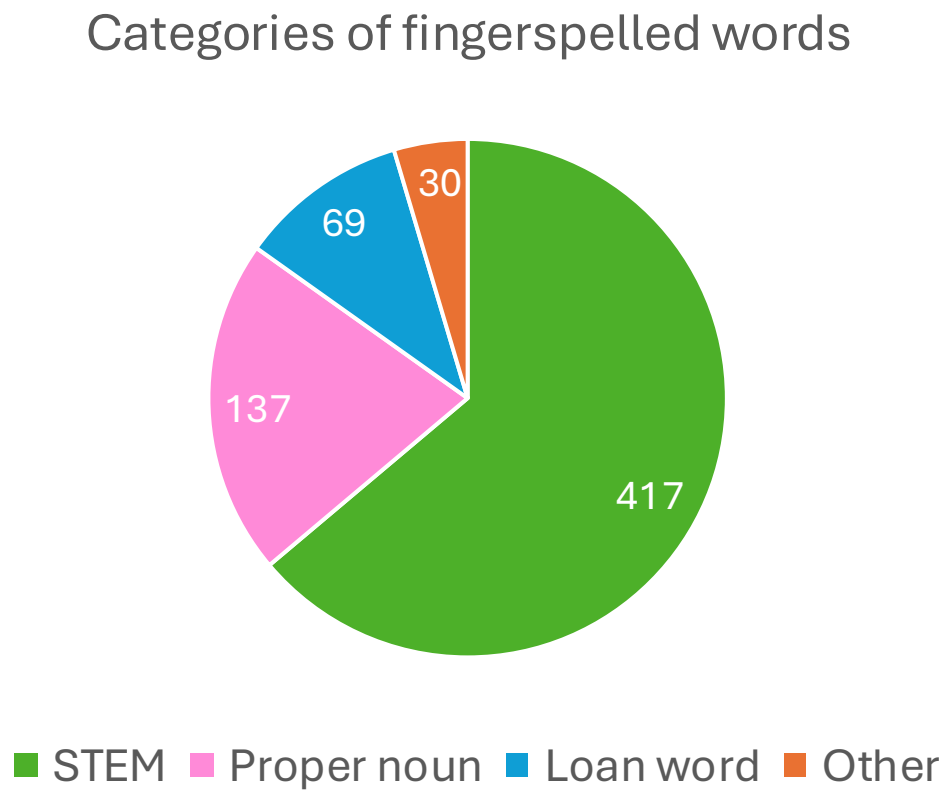
High rate of fingerspelling in ASL STEM Wiki

“Relativistic electromagnetism”

- **Fingerspelling**: spell out an English word using letter signs
- ~6.4% of ASL (Morford and MacFarlane, 2003)
- **~31.5%** of ASL STEM Wiki

High rate of fingerspelling in ASL STEM Wiki

- **63.9%** of fingerspelling is **STEM** words
- Interpreters often resort to fingerspelling when a technical sign is not known



High rate of fingerspelling in ASL STEM Wiki

- 63.
- Inte vhen

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> “[Deaf] students prefer that terms either be signed in ASL, or signed and fingerspelled, as opposed to just fingerspelled.”
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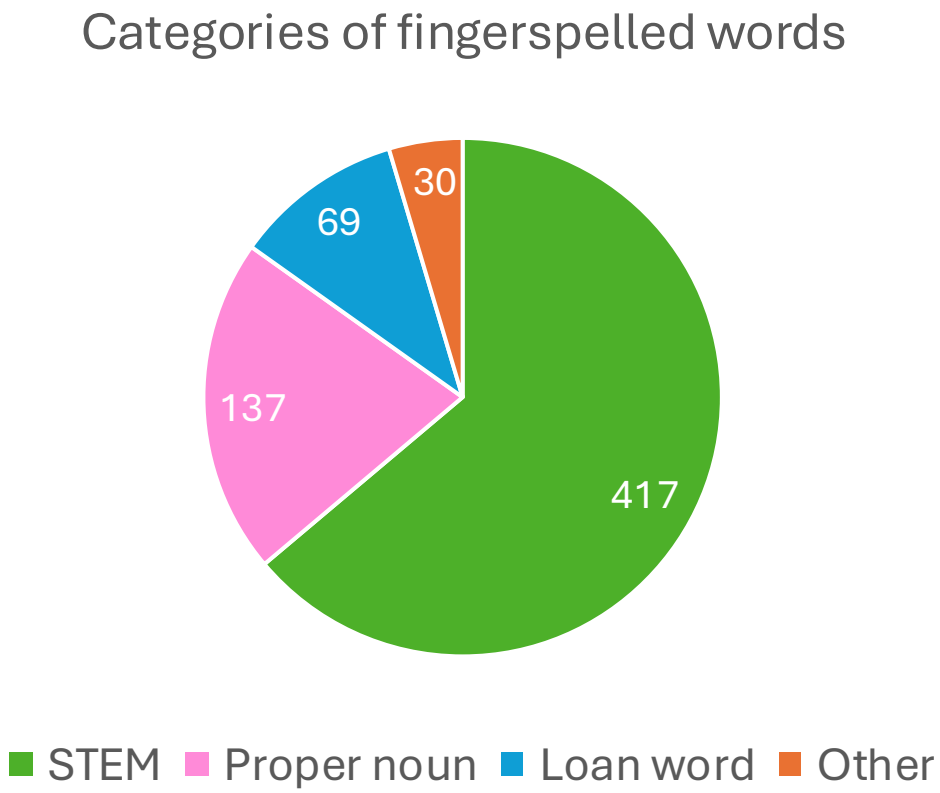
> Development of American Sign Language Guidelines for K-12 Academic Assessments



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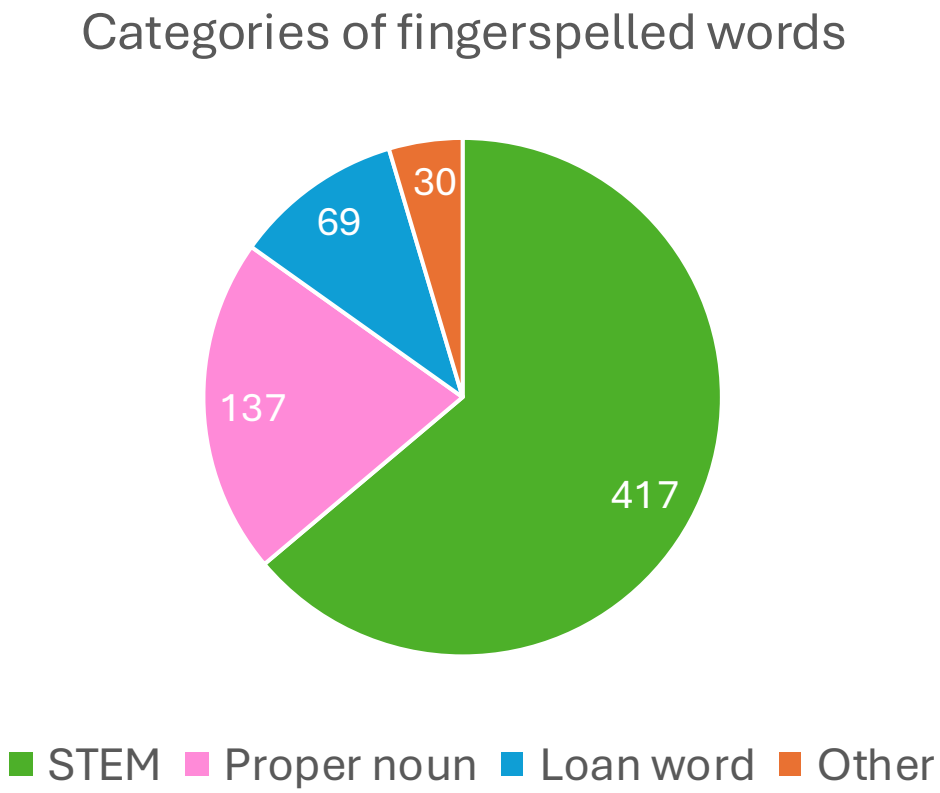


-> Use AI to address the high rate of fingerspelling in STEM

Automatic sign suggestion: task setup

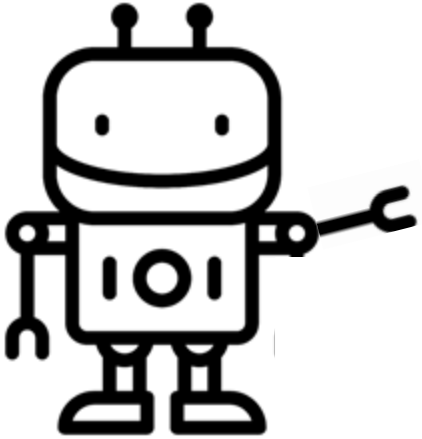
Automatic sign suggestion

User

Automatic sign suggestion

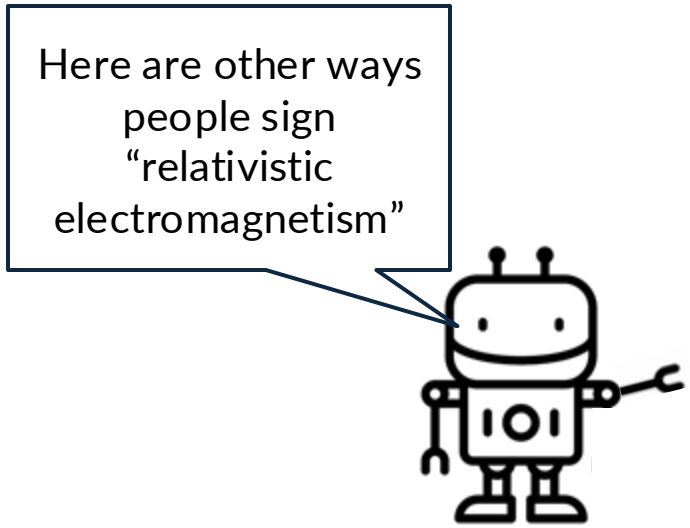
User

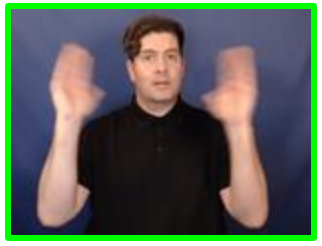
Here are other ways people sign “relativistic electromagnetism”



Automatic sign suggestion

User





3 steps:

1. Fingerspelling detection
2. Fingerspelling alignment
3. Sign retrieval

Automatic sign suggestion

1. Fingerspelling detection
2. Fingerspelling alignment
3. Sign retrieval

Relativistic electromagnetism is a physical phenomenon due to Coulomb's law and Lorentz transformations.

1. Fingerspelling detection

Automatic sign suggestion

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Relativistic electromagnetism

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Relativistic electromagnetism

ASL database

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Relativistic electromagnetism

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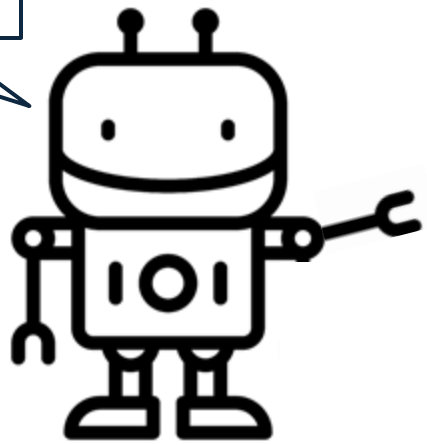


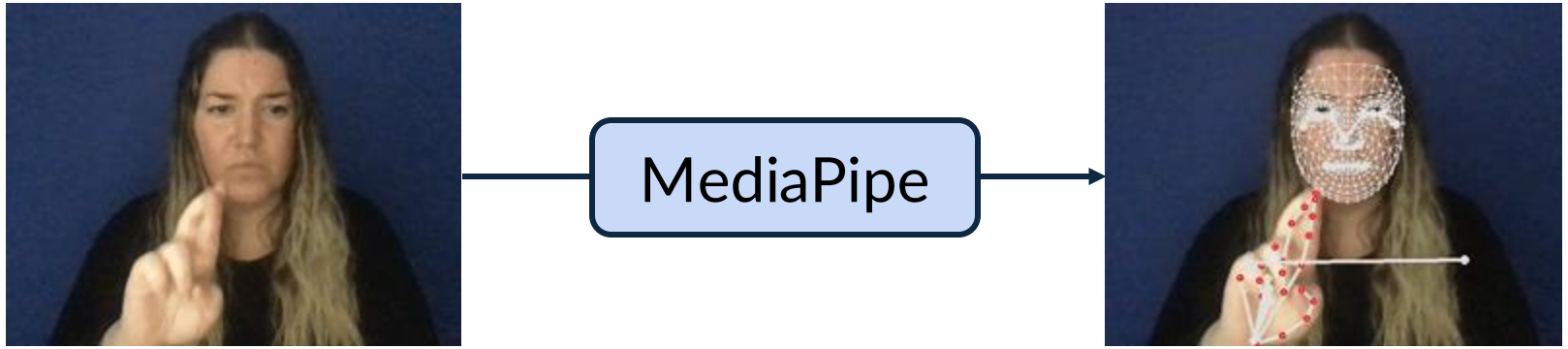
3. Sign retrieval

Methods deep-dive: fingerspelling detection

Fingerspelling detection

Relativistic electromagnetism is a physical phenomenon due to…

Fingerspelling detection



Relativistic electromagnetism is a physical phenomenon due to…

Fingerspelling detection

Relativistic electromagnetism is a physical phenomenon due to…

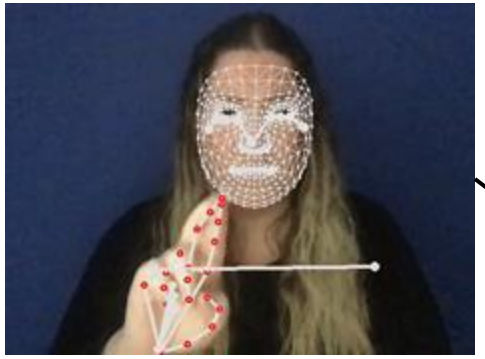
Graph convolutional network

⊕

CANINE
(Clark et al., 2022)

Pre-trained character-level English LM

Fingerspelling detection



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Temporal contrastive learning

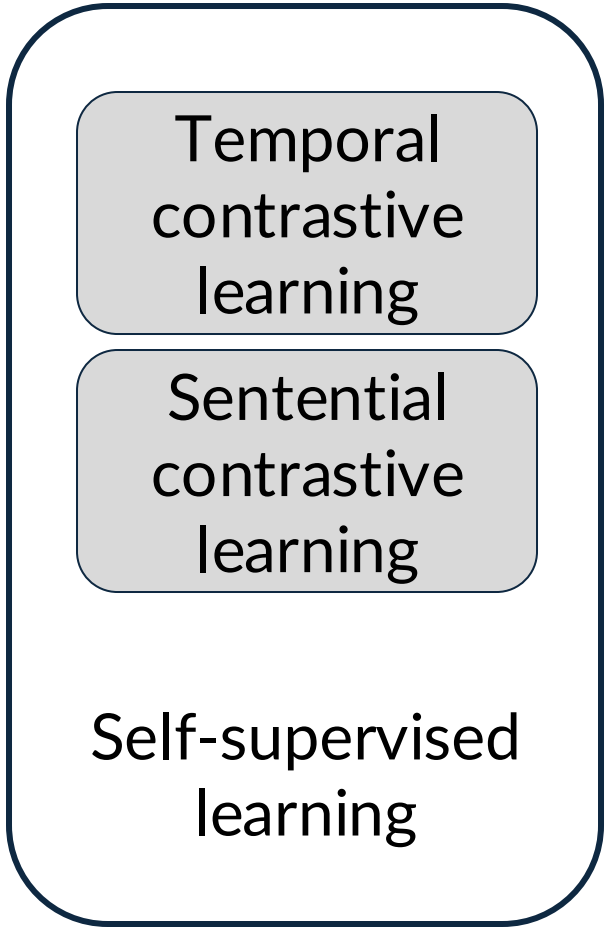
Sentential contrastive learning

Self-supervised learning

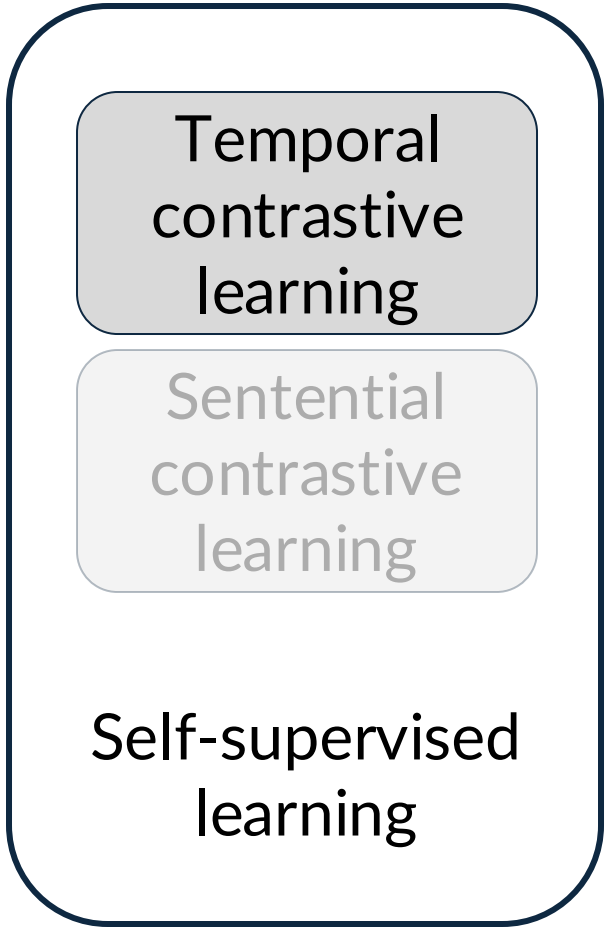
Self-supervised learning

- Self-supervised learning
  - Learn patterns from unannotated data

- Need fingerspelling labels
  - We annotated 507 videos
  - 63,759 unannotated videos



Self-supervised learning



Self-supervised learning

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Self-supervised learning

Model

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Self-supervised learning

Model

Different video

Same video,
video 1 < video 2

Same video,
video 2 < video 1

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Self-supervised learning

Model

Learn representations of the structure and timing of signs

Different video

Same video,
video 1 < video 2

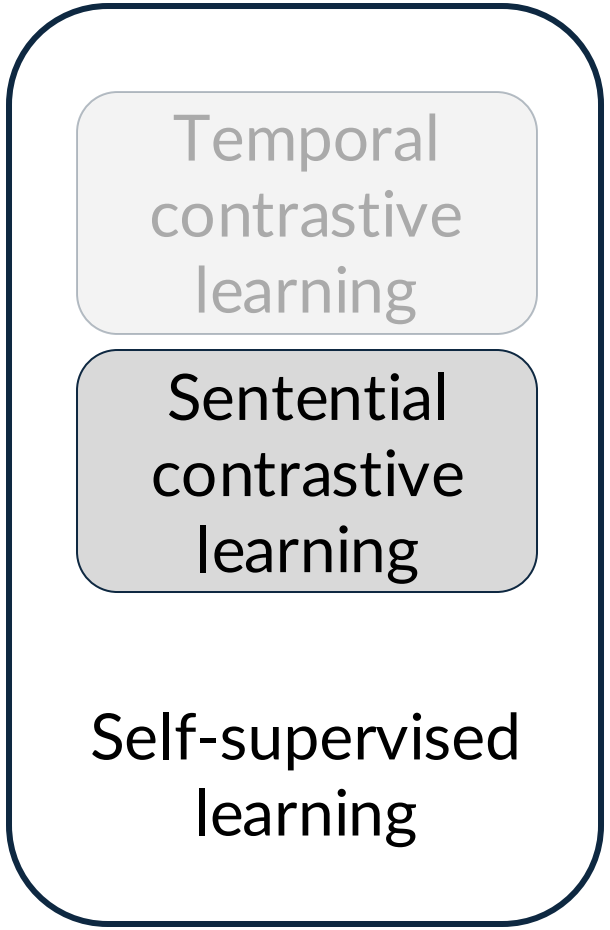
Same video,
video 2 < video 1

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Self-supervised learning



Self-supervised learning

Relativistic electromagnetism is a physical phenomenon due to…

An observer at rest with respect to a system of static, free charges will…

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Self-supervised learning

Relativistic electromagnetism is a physical phenomenon due to…

An observer at rest with respect to a system of static, free charges will…

Model

Temporal contrastive learning

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An observer at rest with respect to a system of static, free charges will…

Model

Video = sentence 1

Video = sentence 2

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Self-supervised learning

Relativistic electromagnetism is a physical phenomenon due to…

An observer at rest with respect to a system of static, free charges will…

Learn associations between ASL videos and English text

Model

Video = sentence 1

Video = sentence 2

Temporal contrastive learning

Sentential contrastive learning

Self-supervised learning

Fingerspelling detection

Relativistic electromagnetism is a physical phenomenon due to…

Graph convolutional network

⊕

CANINE
(Clark et al., 2022)

Temporal contrastive learning

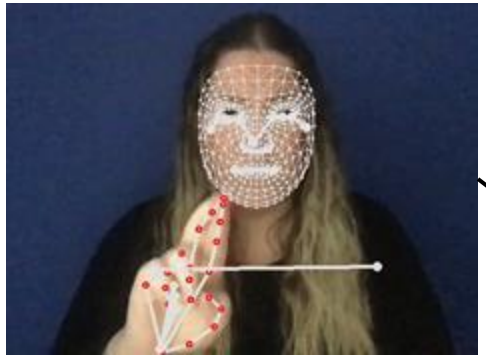
Sentential contrastive learning

Self-supervised learning

Fingerspelling detection

Fine-tuning

Fingerspelling detection



Graph convolutional network

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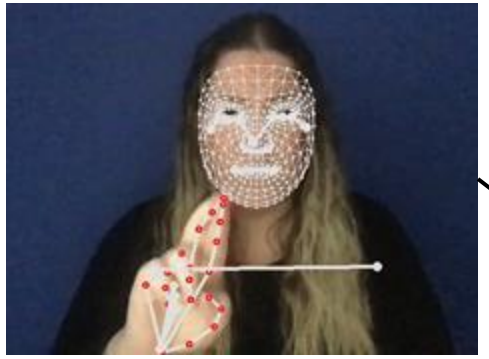

Graph convolutional network

⊕

CANINE
(Clark et al., 2022)

Relativistic electromagnetism is a physical phenomenon due to…

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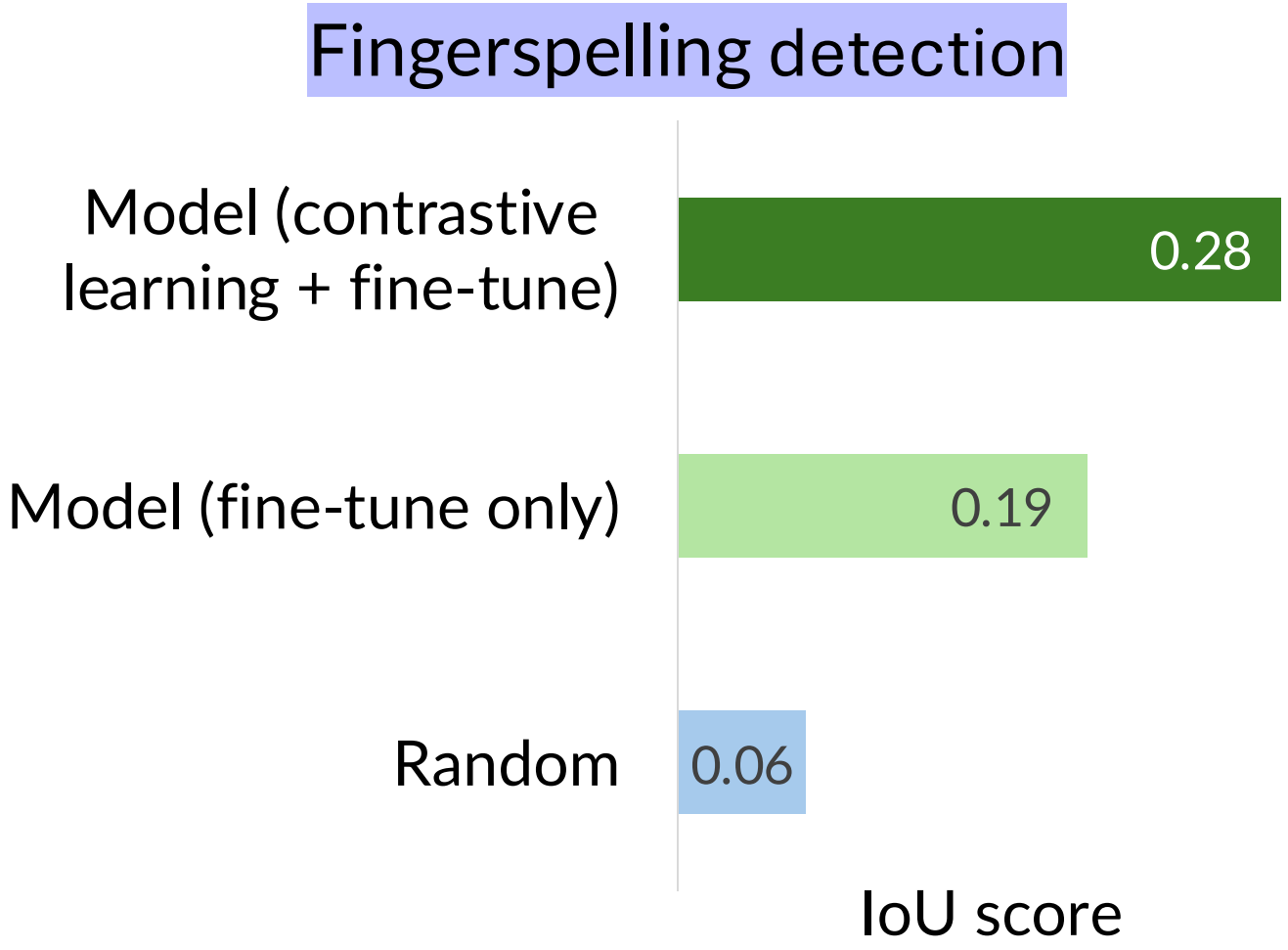
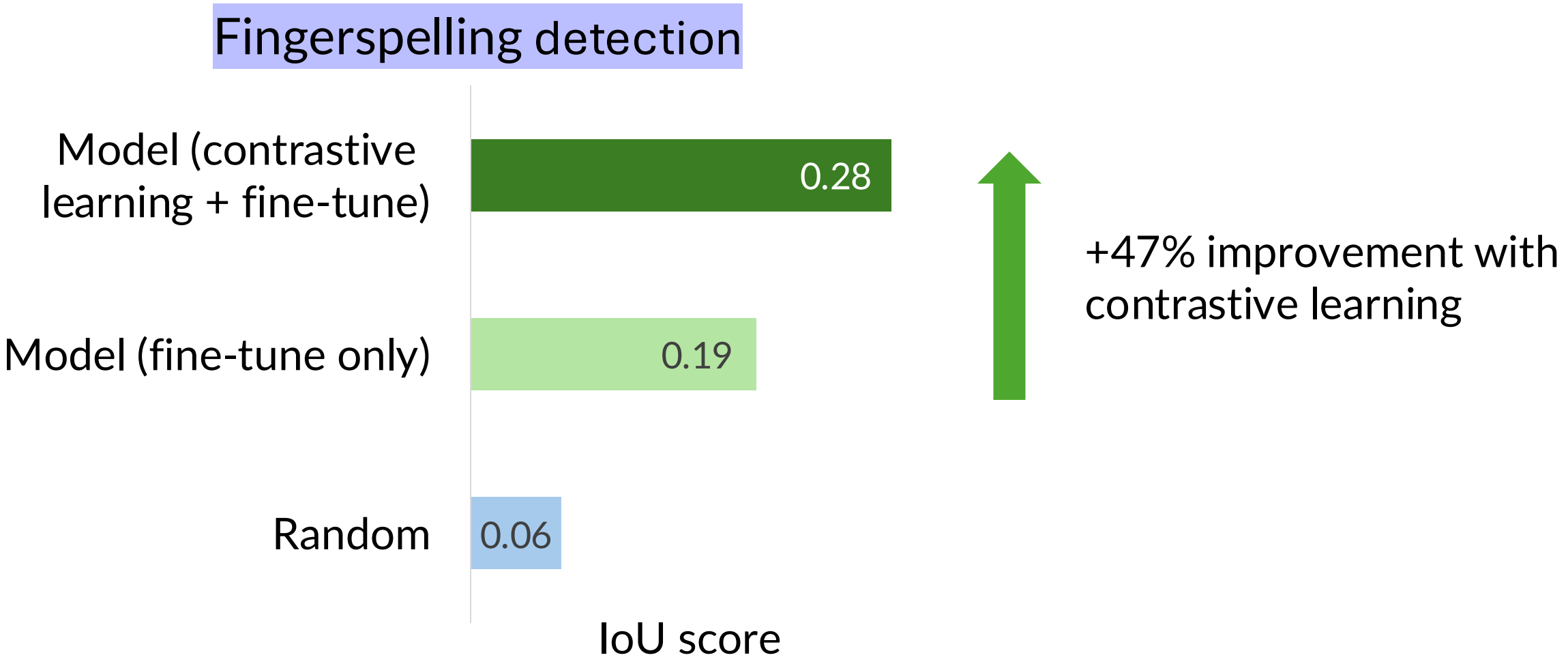
Frame-level detection predictions

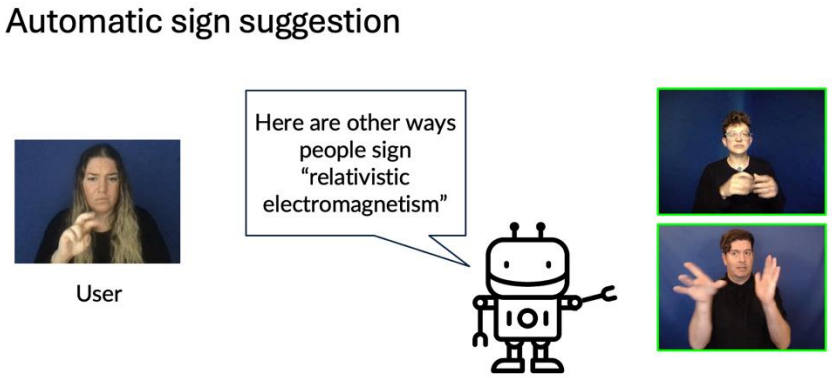
Does contrastive learning work?

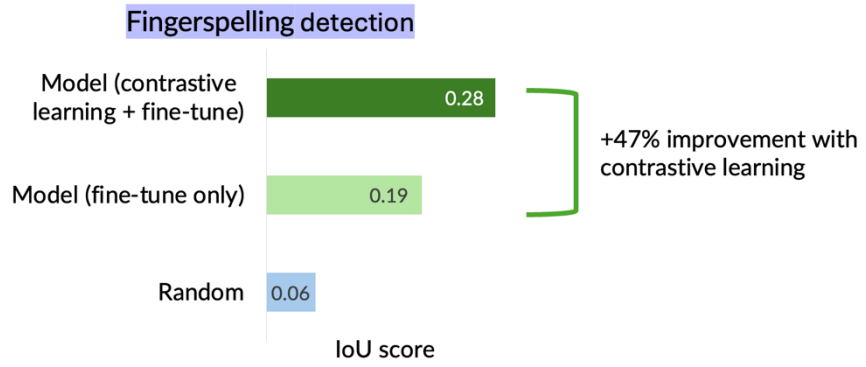


Does contrastive learning work?



Summary





New dataset to support DHH students in STEM

New task to enhance ASL STEM interpretations

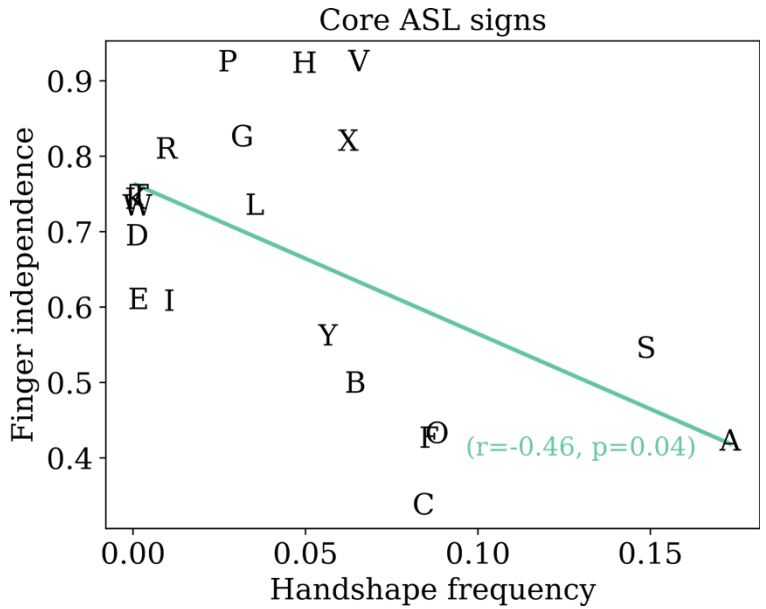
Contrastive learning for sign language modeling

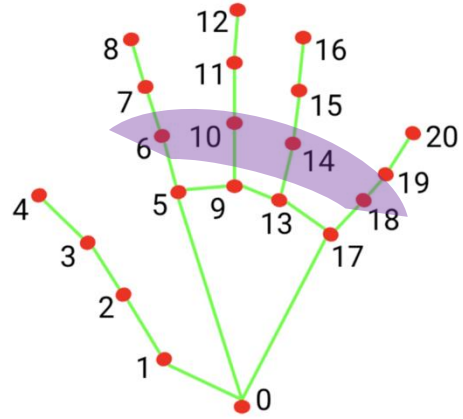
Future directions

“Future” in ASL

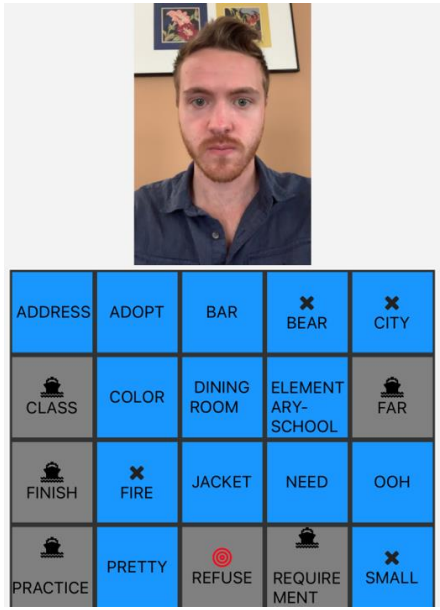
I’m currently working on:

- NLP to verify sign linguistic theories
- Examining representations learned by sign language models
- Evaluation of sign language models





Data collection

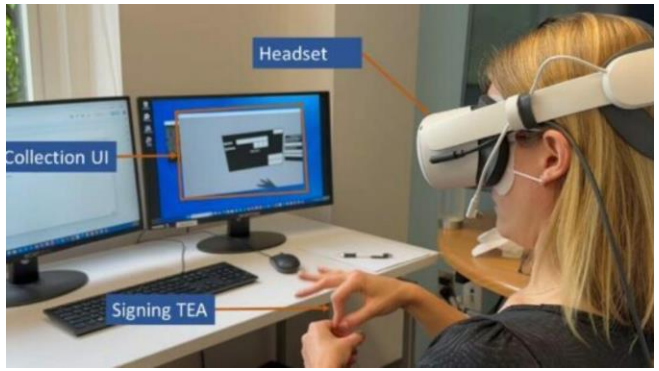


ASL Sea Battle
(Bragg et al., 2021)

- HCI interfaces for data collection
- AI tools to assist data annotation
- AI video anonymization
- Data augmentation

Education

- What environment to learn signed language digitally?
- Adaptive AI for personalized learning
- Educational content delivery, real-time classroom support



ASL Champ
(Gallaudet, 2024)

Signed language generation

Here Comes Mavo!
(Gallaudet, 2025)

- What does a good signing avatar look like?
- Translation between signed languages
- Storytelling

The end!

Road trip to Gallaudet University (Dec. 2021)

CMU SCS The Link (Winter 2021)

Some highlights from my time researching signed languages at CMU ☺