# SignQuery: A Natural User Interface and Search Engine for Sign Languages with Wearable Sensors

**Hao Zhou**, Taiting Lu, Kristina McKinnie, Joseph Palagano
**Kenneth DeHaan**, Mahanth Gowda



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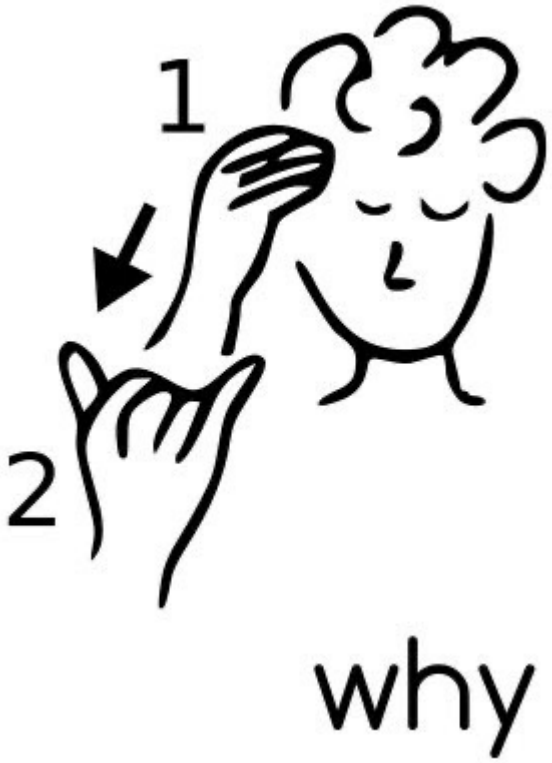
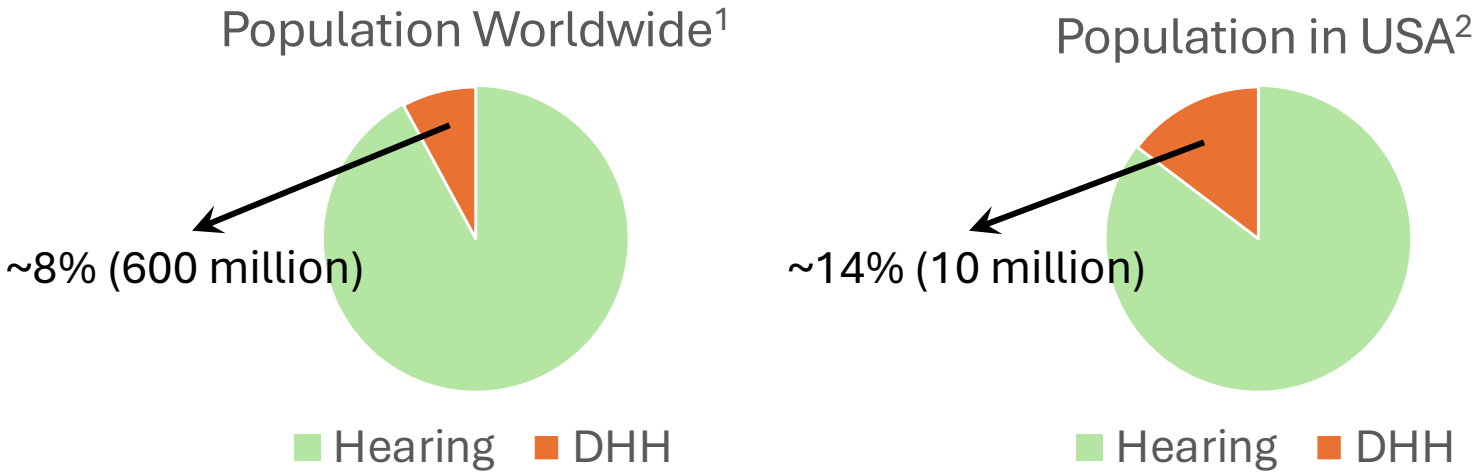
**Why** do we want to build a search engine with sign languages?



# The Deaf and Hard of Hearing community is a part of the world.



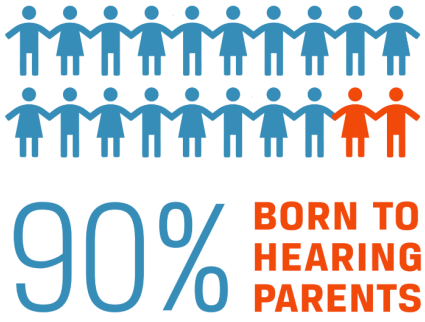

**Accessibility and Inclusion**: To create a more inclusive digital environment for the Deaf and Hard of Hearing (DHH) community so that they communicate in their native language on the internet and beyond.

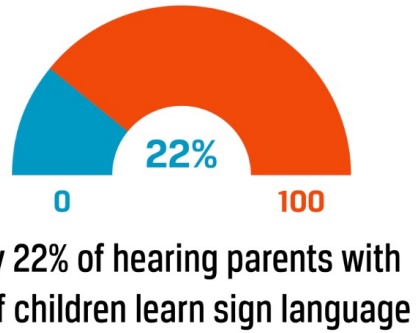
# Text search is indeed an option, but...

we ignored one important fact...
**Language Deprivation and Literacy Challenges**[3]


- 90% of deaf children are born into a hearing family.

- deaf children may not naturally and stably achieve fluency in any language without a frequent and accessible environment in their native language, sign language, before the age of four.



## Signing is more natural to the DHH community.

**Natural and Intuitive Interaction:** signing is a natural and intuitive process. Allowing queries through signs can make the search experience more fluid and instinctive for them.

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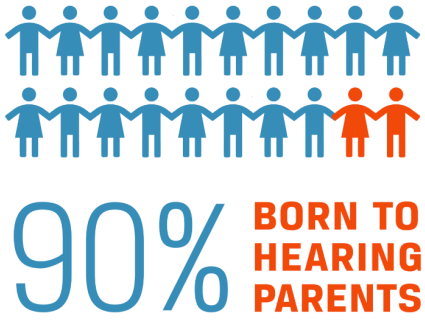
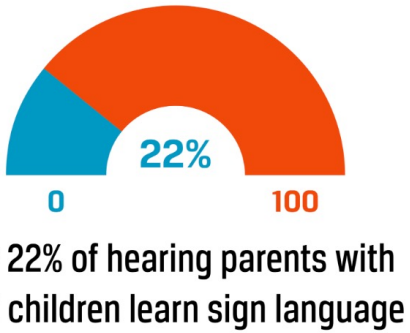


**How** to enable direct sign search?

# Related work: Translating signs into text before searching

Video based sign language translation systems[4,5] as an example

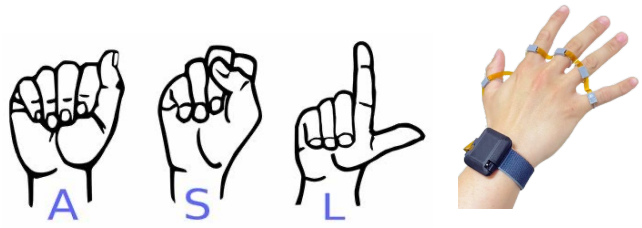
Sign Videos → Machine Learning Models → Translation Result

These systems require video inputs, which
- exposes private personal information,
- is sensitive to lightness, occlusions, etc.
- is not ubiquitous.

Importantly, they are still text-based.
(recall existing Language Deprivation and Literacy Challenges)

# SignQuery

Signs are captured by our IMU device.

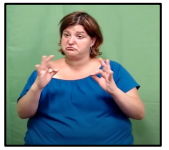



Storage for all documents

Outcomes

“Cut tomatoes into cubes”

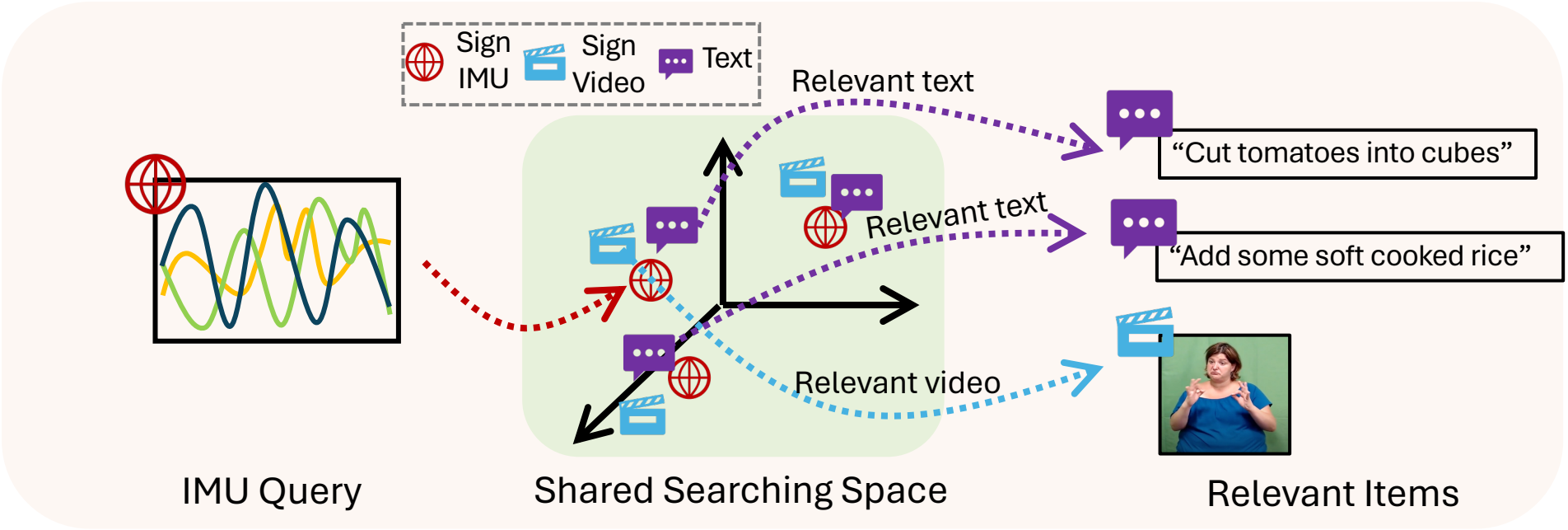
“Add some soft cooked rice”



⋮

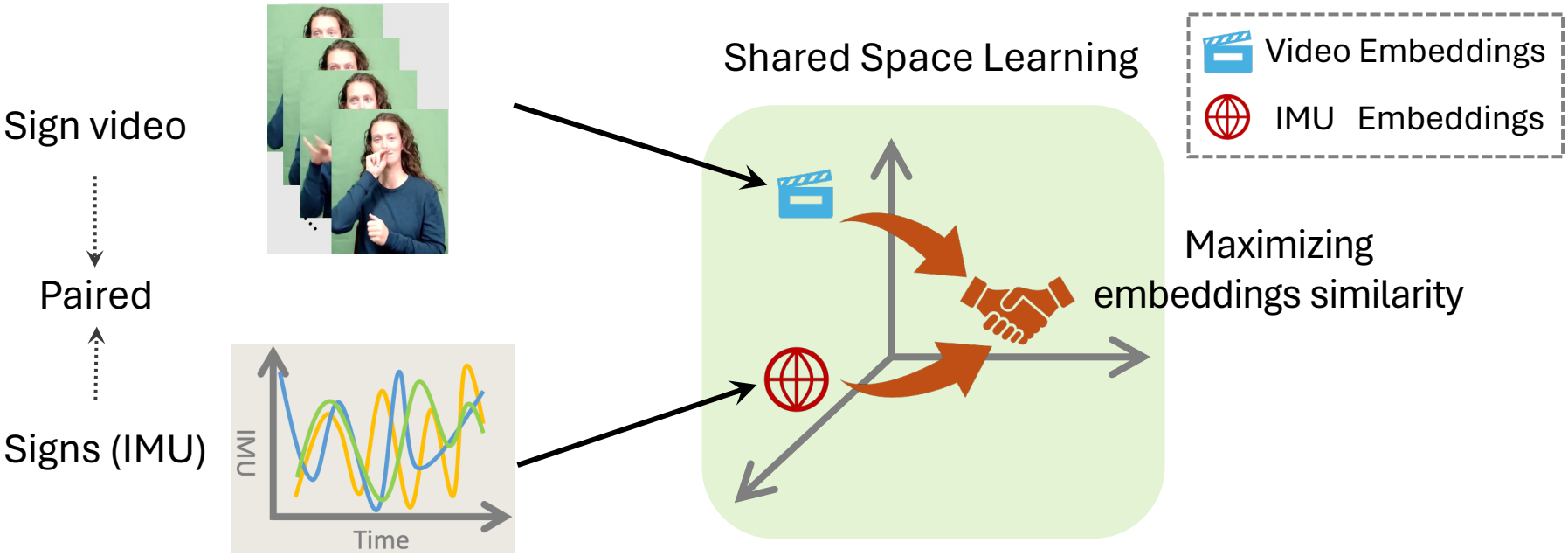
**A recommendation system that supports a more natural way of searching (signing vs texting) for the DHH community, thus promoting accessibility and ensuring equitable access principles for all Deaf users to search online.**

# Key Idea: Encoding different modalities into a shared search space




**SignQuery supports direct sign search (in form of IMU) directly in a shared space and returns relevant items.**

# How to build shared search space with different modalities?



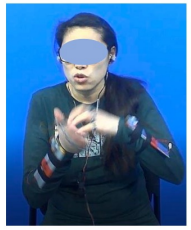

Observation: video contents are more complex and richer than that of IMU signals

➢ made the learned shared space ineffective

# Video vs. IMU signal


- Video contents tent to be more complex and richer
  - lots of redundancy
  - insignificant information from background

User 1



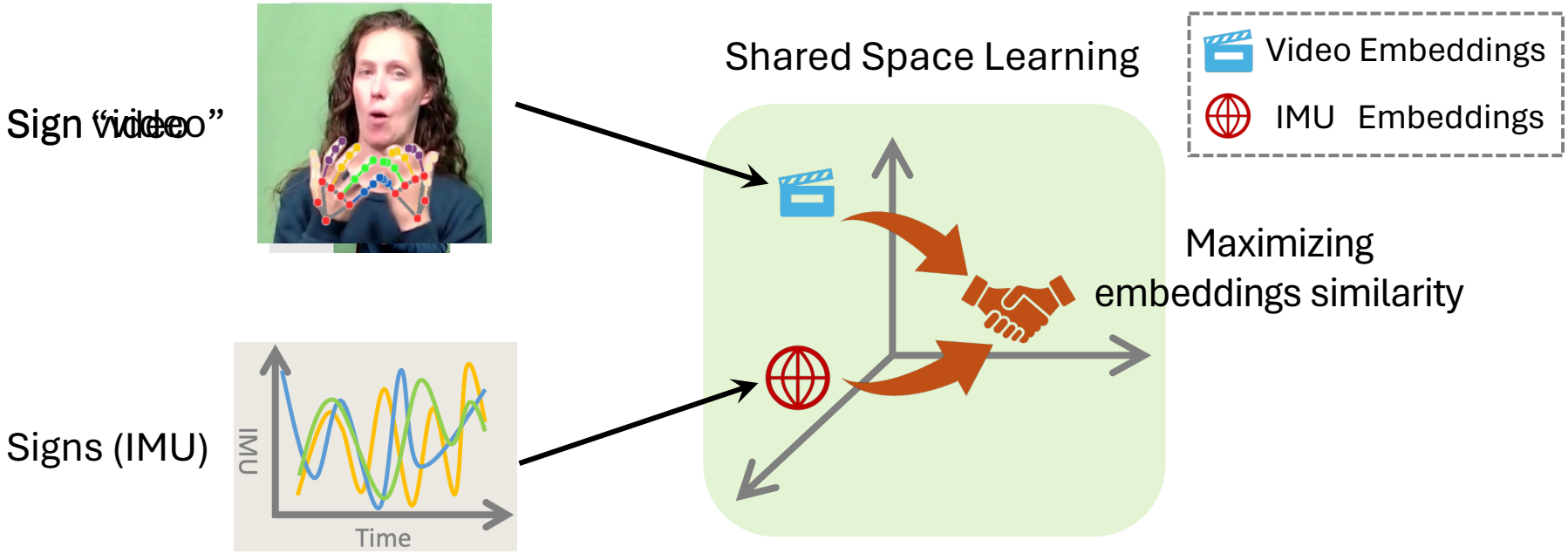
User 2

- Users might have different facial expressions even they were signing for the same thing

- While IMU signals contain information from hands only

**We need to simplify videos to make the learning process efficient.**

# Video Simplification




Instead of embedding sign videos directly, we simplify videos by extracting hand joint locations, then embed "videos" with IMU signals.

# Evaluation

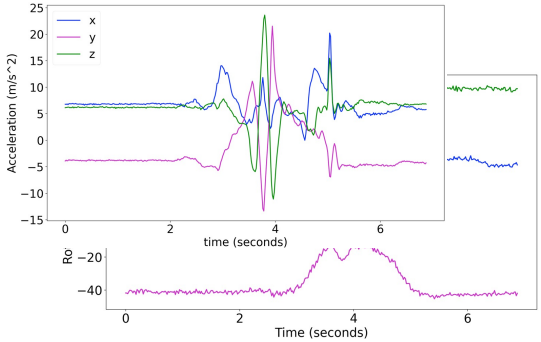
**Training Data Details**

- adopting from How2Sign[6]
- cover various of topics such as sports, arts, personal care, education.

**Our User Study Details (Testing Data)**

- 12 native ASL signers from D.C. area (mainly GU).

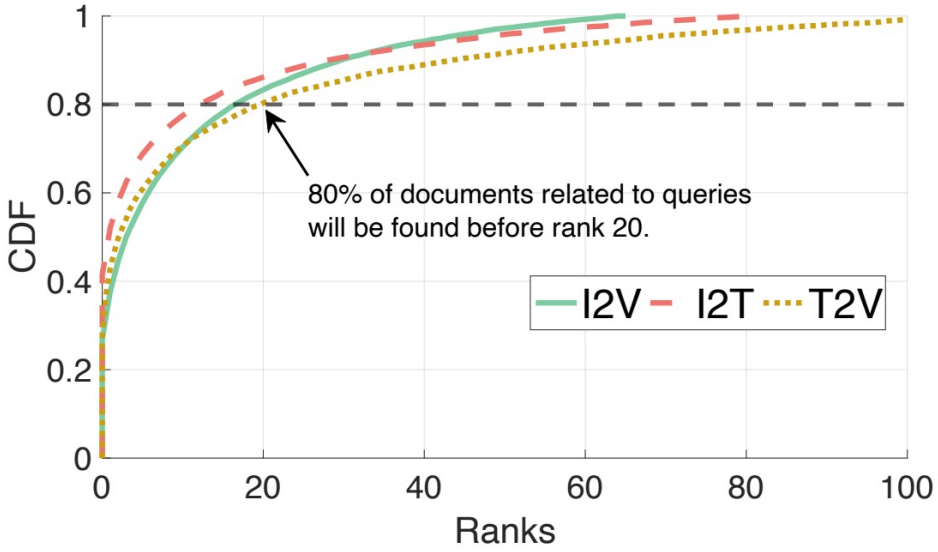
| Properties | *How2Sign* [32] (Train/Evaluation) | *SignQuery* (Ours) (Test) |
|---|---|---|
| Language | ASL | ASL |
| Duration (h) | 79 | 24 |
| No. of Signers | 11 | 12 |
| No. of Sentences | 24109 / 3178 | 2571 |
| Modality | Video, Text | Video, Text, IMU |




Gloss **SEE IX CHAMP3**

English **I am happy to see you!**

# Evaluation

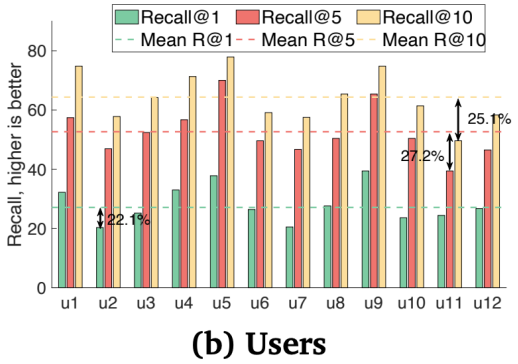



**(a) Rank Distributions**

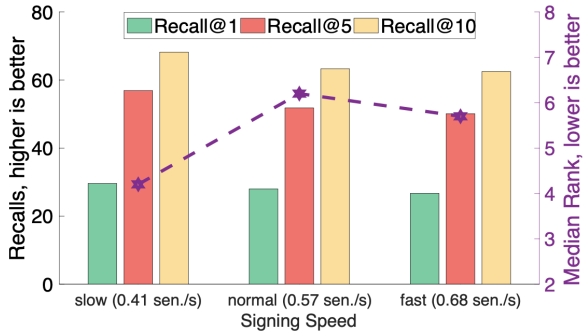
More than 80% of documents that are related to queries can be found before rank 20 (from 24k).

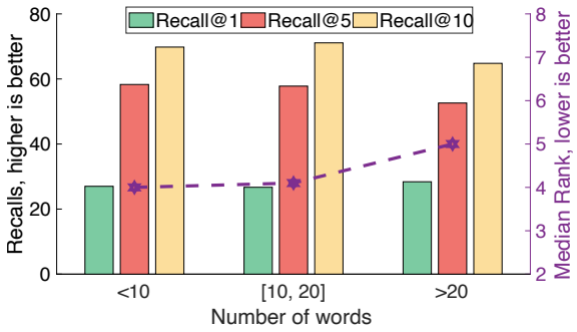
*__I2V__ is to use __I__MU as queries and returning __V__ideos as results

# Evaluation



(b) Users



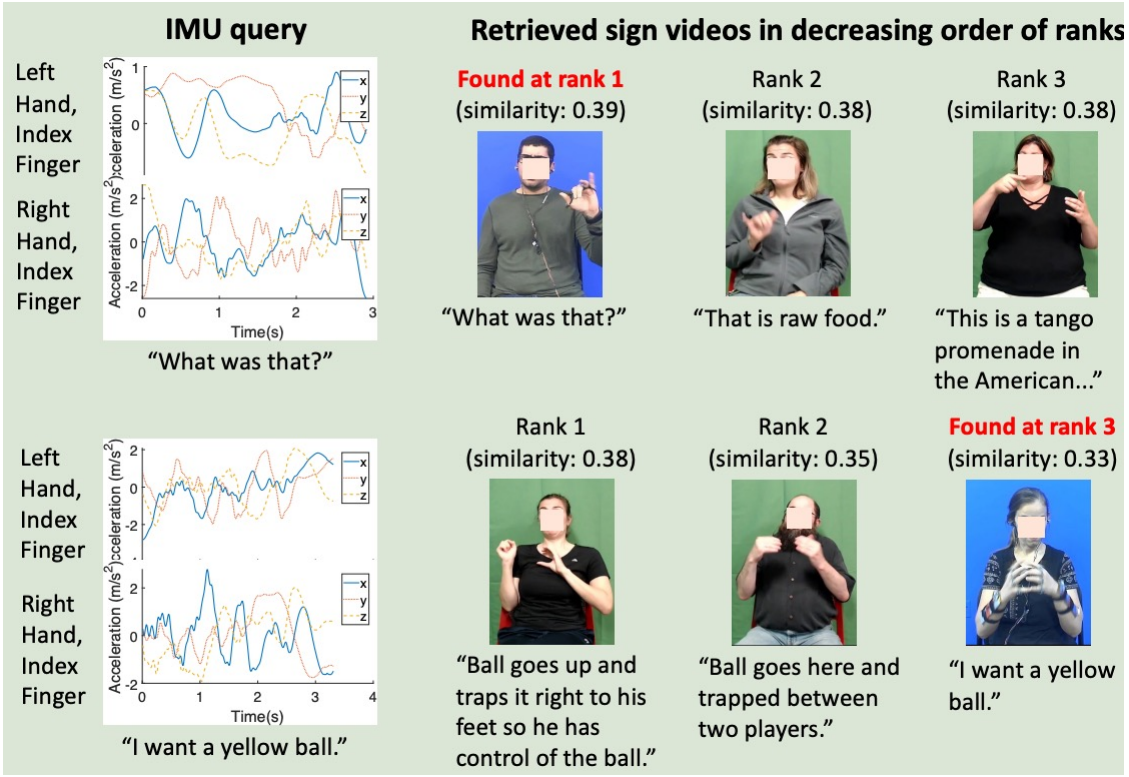




SignQuery performs well with 12 new users in our user study.

Stable across various signing speeds.

Stable across various sentence lengths

# Evaluation



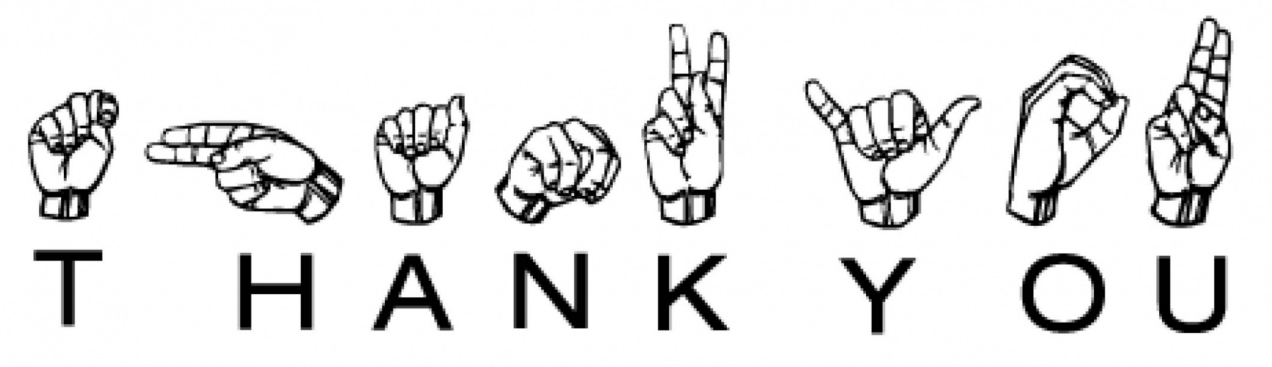

Using IMU as queries, relevant documents (e.g., sign videos) can be retrieved accurately.

## Take-aways

**Signing is always preferred in the DHH community.** SignQuery is the first system to support native signs, thus ensuring equitable access principles for all Deaf users to search online.

**Embedding all into one is our solution** to eliminate the need of text that might not be available for all Deaf people.

**SignQuery and its beyond.** We believe current version of SignQuery only demonstrates a part of its potential. Other applications such as ASL animation, Sign Language Recognition can be extended on top of SignQuery.




Contact: **Hao Zhou / hao.zhou@psu.edu**

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