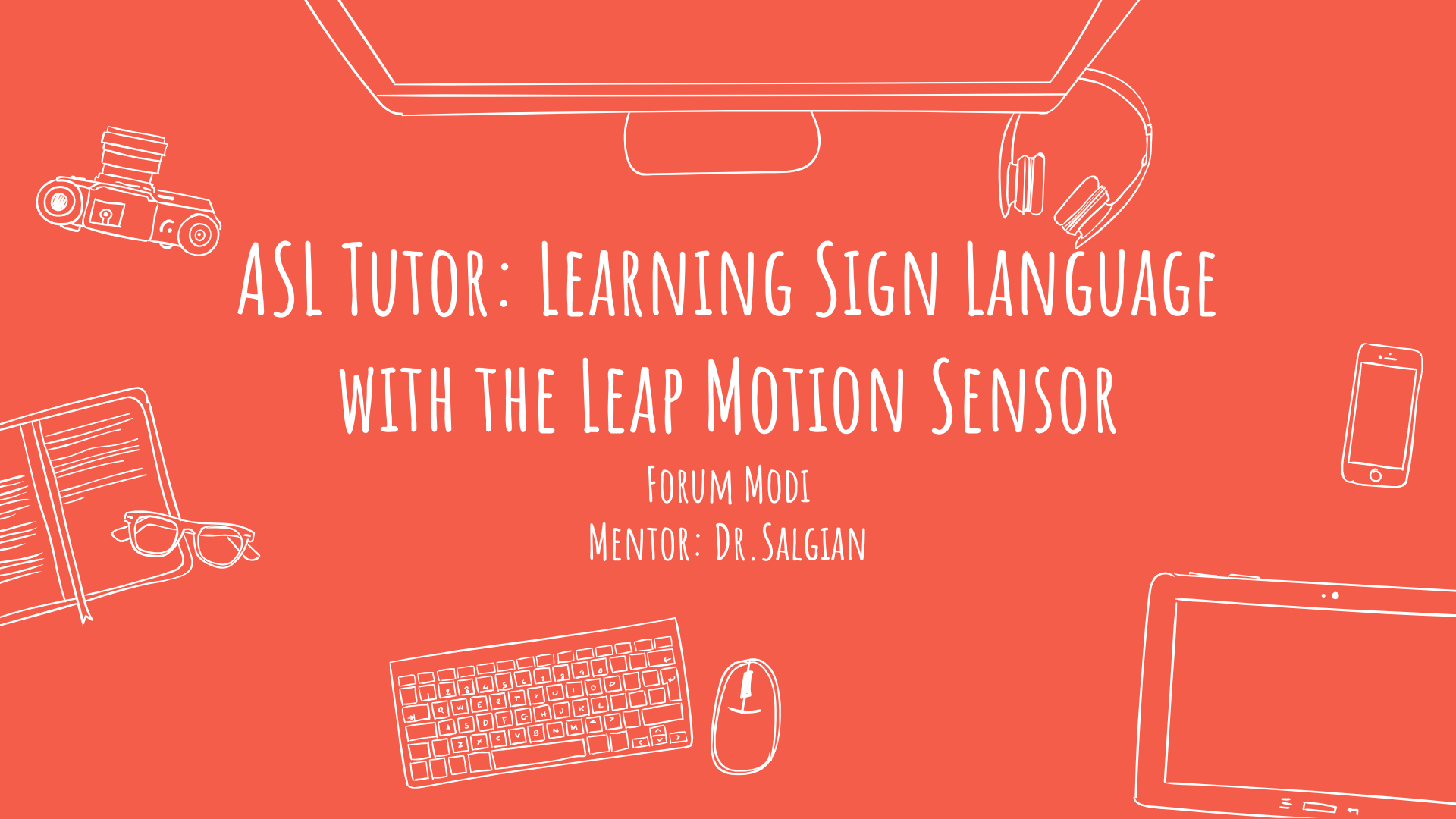


ASL Tutor: Learning Sign Language with the Leap Motion Sensor

Forum Modi
Mentor: Dr. Salgian

Background

- "90% of children who are deaf are born to families who can hear" [Sheetz 2012]
- Deaf or Hard of Hearing (DHH) individuals typically rely on sign languages that use visual gestures to communicate.
- In the US, American Sign Language (ASL) is primarily used.
    - Two types of signs: static (fixed) signs, dynamic (moving) signs
- Unlike other languages, it is difficult to simply look up a sign to learn it
    - Resources online: one-dimensional videos, written descriptions
- There is much research related to sign language translation to written language, but not many systems that teach sign language.
    - Aside from two hackathon projects with no formal testing

Background(Cont.)

Sign Recognition

- assumes a user knows how to do the sign
- translates the performed sign into written English

Sign Validation

- assumes the user does not know the sign
- gives user either negative or positive feedback on how correctly the sign was performed

By using approaches to sign language translation, one could create a practical and scalable system that effectively teaches ASL signs.

Related Work

The following systems utilized the Leap Motion Sensor for ASL translation

Canavan, Mapari, Almeda, Chophuk, and Chong Systems

- ✖ Static Machine Learning approach: not easily scalable
- ✖ Static Decision Tree Approach: scalable, only static signs
- ✖ Dynamic + Static Machine learning approach: not easily scalable

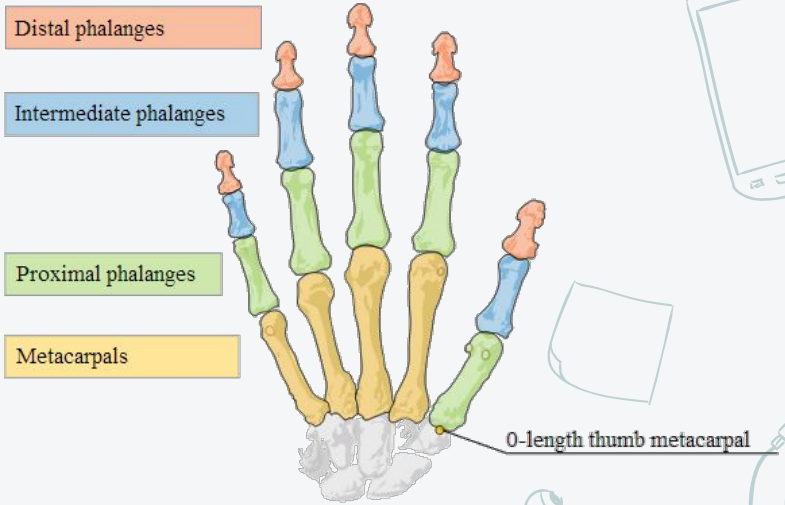
Tom Orth's System

- ✖ Dynamic + Static Feature ID Approach : easily scalable
- ✖ Built in functionality to add signs
  - Using a similar feature ID list could result in a practical and scalable system that effectively teaches ASL signs.

System Setup - Leap Motion

Leap Motion

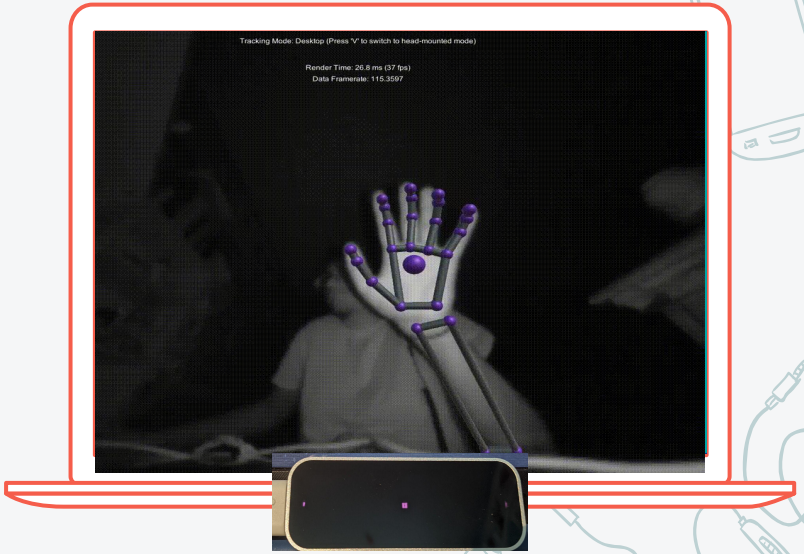
- Hand tracking sensor
  - Uses two infrared cameras
  - Tracks palm, wrist, bones for each finger
- Leap Motion API used to obtain information about movement



System Setup - Leap Motion

Visualizer

- Leap Motion comes with a visualizer shown on the left
  - Shows a skeletal model of the hands movement



Leap Orientation

- The Leap Motion tracks more accurately at an angle [Orth 2020], so it was oriented up by 60 degrees

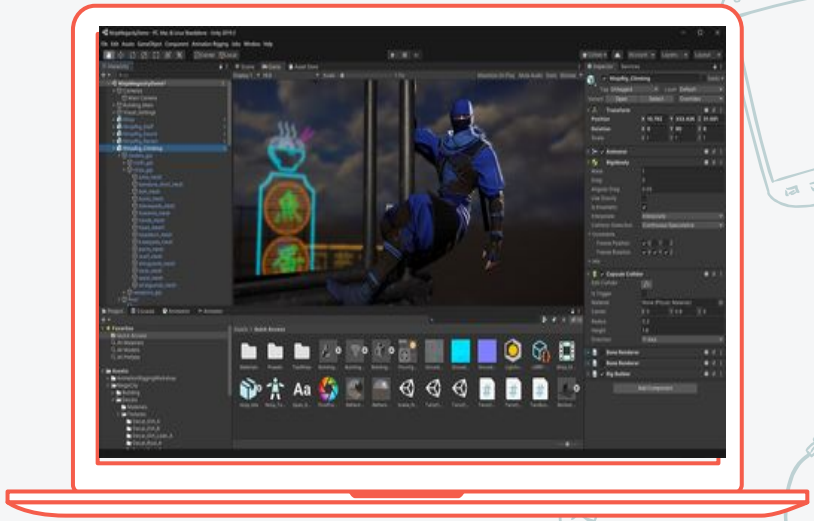
System Setup - Unity

Unity

- Game development editor for both 3D and 2D application for a diverse array of platforms

Unity Leap Motion SDK

- SDK tool for Unity development with access to Leap API functions



Visual of Unity Editor

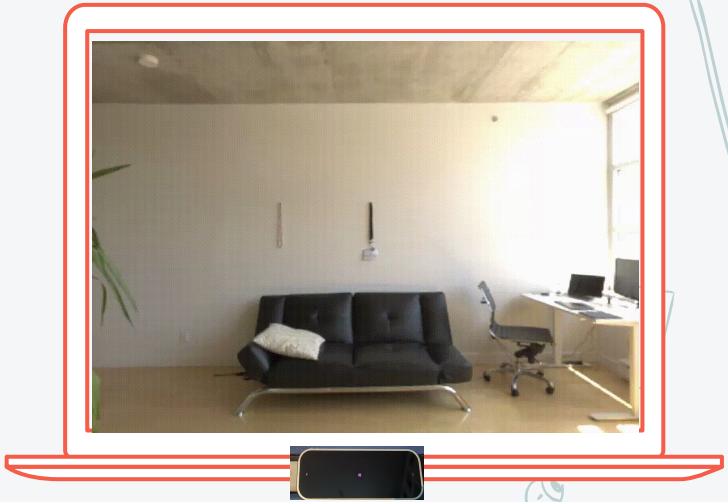
System Setup - Unity

Realistic Hand Asset

- From Unity Asset Store
- 3D model of realistic hands that represents Leap Motions hand tracking

Platform Compatibility

- Unity Leap Motion SDK only works for Windows
- Sorry Mac users!



Realistic hand asset tracks the hands and projects on screen

Sign Representation

- The sign representation for this system was derived using a similar data structure to Orth using a feature ID list.
- Every sign is represented as a list of features using the Leap API.
- When a feature is present, its ID number is in the feature ID list.
- There are categories of features:
  - Static
  - Dynamic

Sign Representation

Static Features

- Presence of two hands over the sensor
- For each hand
  - Palm facing the leap motion sensor
  - Fingers facing up
  - Middle and Index Finger touching
- For each finger
  - Finger is extended.
  - Finger is bent.

Dynamic Features

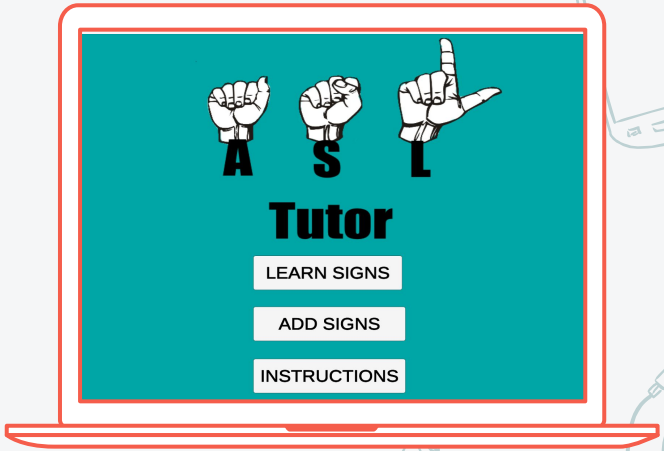
- For both hands
  - Noticeable movement in the X direction of the palm
  - Noticeable movement in the Z direction of the palm
  - Noticeable movement in the X direction of the distal bone of the index finger
- For each finger
  - Noticeable movement in the Y direction of the distal bone

Features were determined to be present or not using the Leap API

User Interface

For learning sign language, users need visual feedback to...

- view the sign
- view feedback on their signing ability



Unity was used to develop an application, called ASLTutor, that teaches users signs

Learning Signs

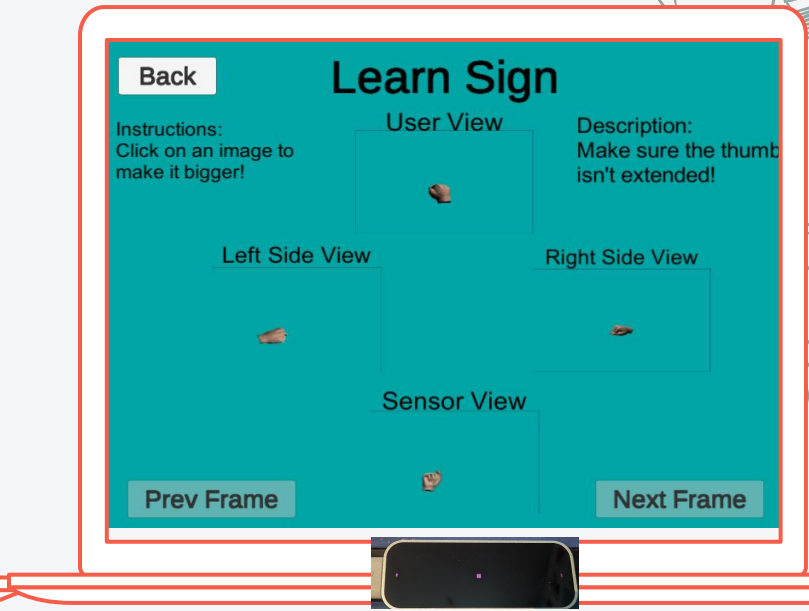
- Users have the ability to learn signs and be given feedback
  - There are 42 signs (30 static and 12 dynamic) already in the system

Learning the sign

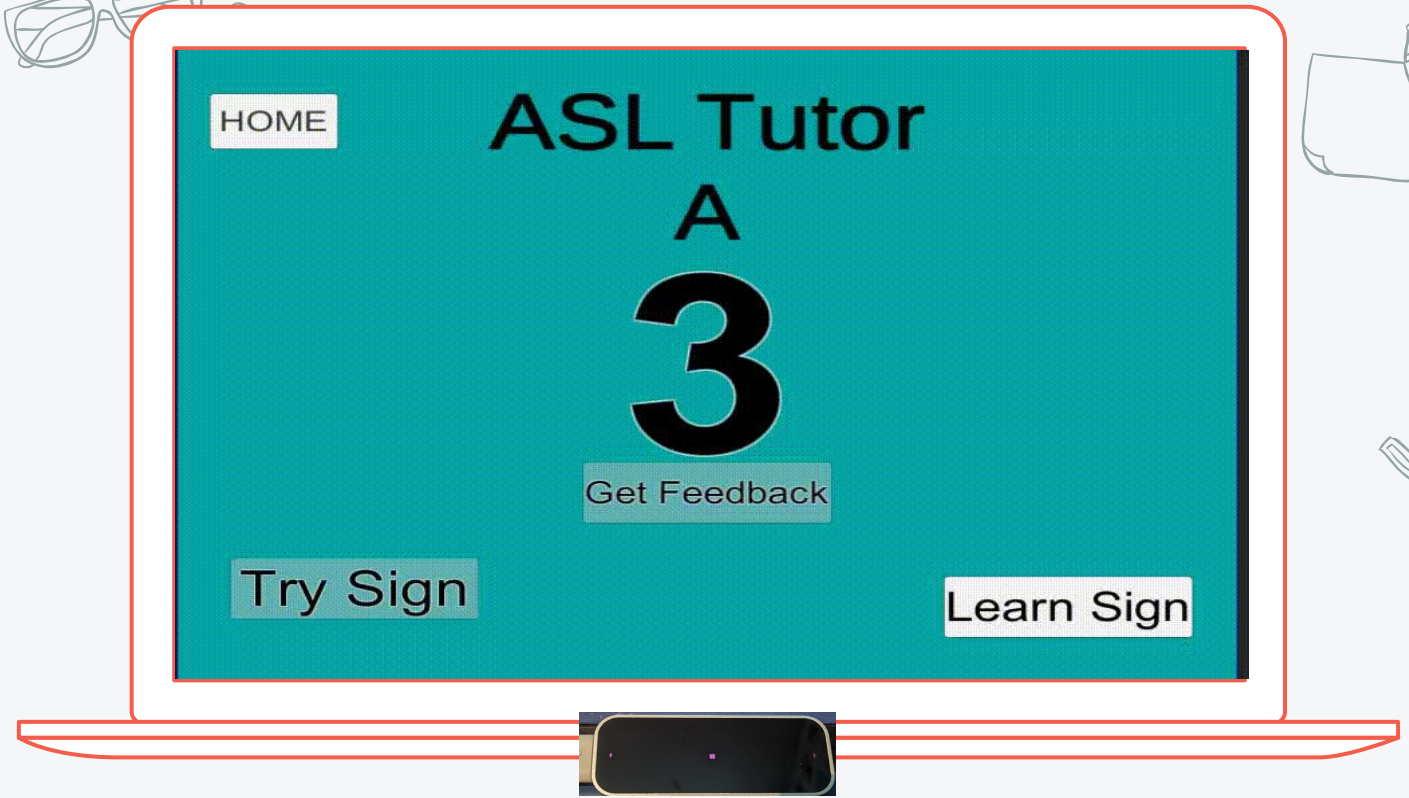
- The user can view images of four angles of the hand doing the sign with a short description

Trying the sign

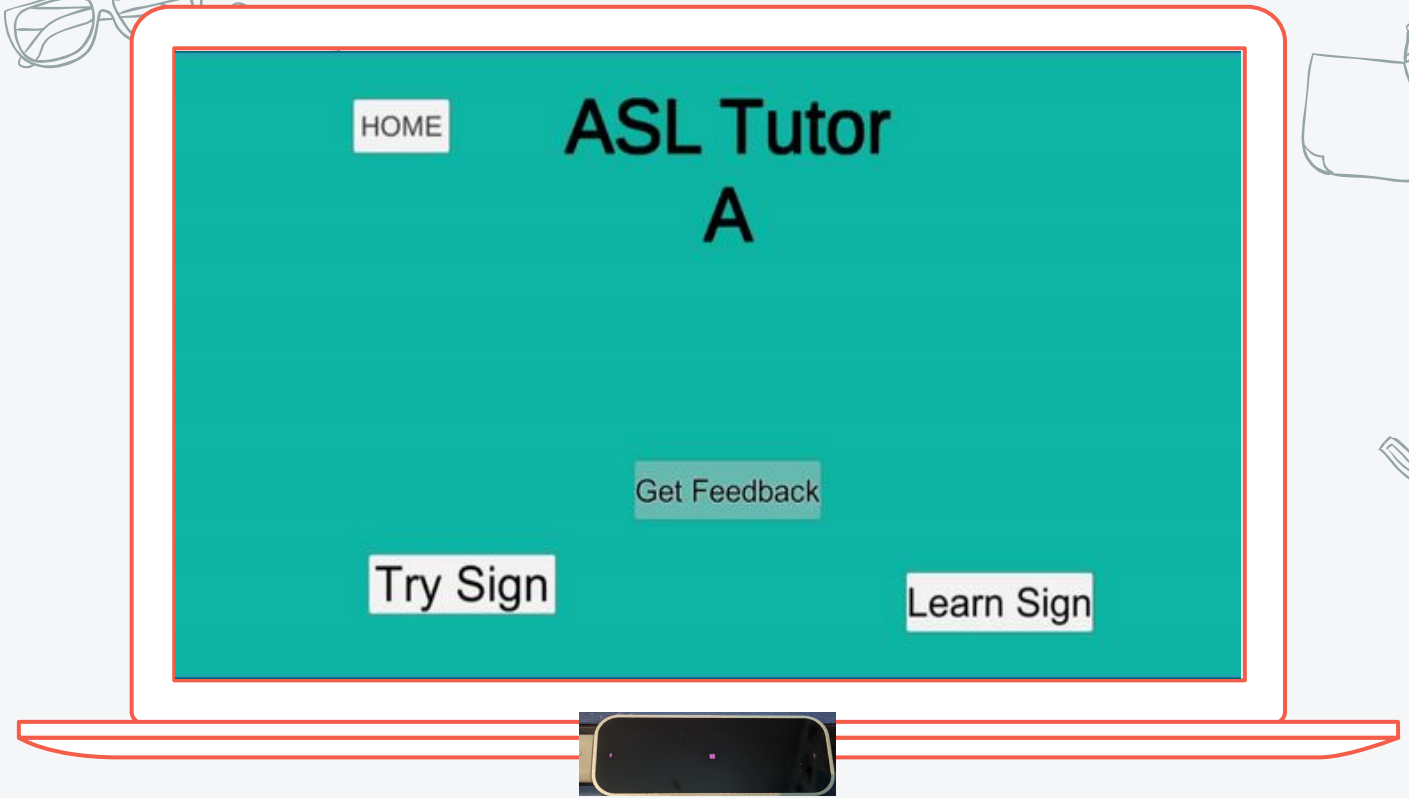
- The user attempts the sign and is given positive or negative feedback
- For feedback, the feature ID list of the user attempting the sign is obtained and compared to the sign's expected feature ID



User Interface: Learning Signs



User Interface: Learning Signs



User Interface: Learning Signs

Adding Signs

- Users have the ability to add signs to the system
  - Can be a teacher or ASL signer
- Users are prompted to perform the sign on the screen through a countdown
  - static features are obtained in the first frame
  - dynamic features are obtained over the course of several frames until hand is no longer moving
  - A feature ID list is obtained and added to a text file of all signs once the user presses "Add Signs"
- Users can also add images of signs for reference later

User Interface: ADDING Signs

EVALUATION AND RESULTS

Users were asked to test the system, given no guidance other than how to use the Leap Motion Sensor.

- Subject with basic ASL knowledge tested full system of 42 signs
  - 2 signs gave negative feedback for correctly doing sign
  - 2 signs gave positive feedback when incorrectly done
  - 4 signs gave gave slightly incorrect feedback
  - Subject had success adding dynamic + static signs
- Two Subjects with little ASL knowledge tested learning nickname, 3 dynamic signs, and 1 other static sign
  - Were able to learn signs from images/descriptions
  - Both could not get correct feedback for one dynamic sign
  - Both remembered how to spell nickname after testing

EVALUATION AND RESULTS

- Subject with no ASL knowledge tested static + dynamic signs
  - Correctly performed 4 static signs
  - Difficulty learning and correctly performing dynamic signs
    - User was left-handed

Possible Sources of Error

- Insufficient testing for feature thresholds
  - Would be improved with more testing
- Leap Motion Inaccuracy
  - The Leap Motion does not always accurately detect the hands movement.
    - Dynamic signs are impacted by this often

Future work and conclusion

- Add more features for better feedback
  - allows for a better sign representation
  - would require more testing
- Presenting users with an animated hand that can rotate in 360 degrees instead of images
- More modern-looking interface
- More usability testing in general

Bibliography

Almeda, S. 2019. Accessible American Sign Language Recognition with the Leap Motion Controller. *In Proceedings of the 50th ACM Technical Symposium on Computer Science Education*. 1293–1293.

Canavan S., Keyes W., Mccormick R., Kunnumpurath J., Hoelzel T., and Yin L., "Hand gesture recognition using a skeleton-based feature representation with a random regression forest," 2017 IEEE International Conference on Image Processing (ICIP), Beijing, China, 2017, pp. 2364-2368, doi: 10.1109/ICIP.2017.8296705.

Chong, T. and Lee, B. 2018. American Sign Language Recognition Using Leap Motion Controller with Machine Learning Approach. *Sensors (Basel, Switzerland)* 18, 10 (19 Oct 2018), 3554. https://doi.org/10.3390/s18103554

Chophuk P., Pattanaworapan K. and Chamnongthai K., "Fist american sign language recognition using leap motion sensor," 2018 International Workshop on Advanced Image Technology (IWAIT), Chiang Mai, Thailand, 2018, pp. 1-4, doi: 10.1109/IWAIT.2018.8369790.

Mapari, R. B. and Kharat, G. 2016. American Static Signs Recognition Using Leap Motion Sensor. In Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies (ICTCS '16). Association for Computing Machinery, New York, NY, USA, Article 67, 1–5. DOI: https://doi.org/10.1145/2905055.2905125.

Orth, Tom 2020. Real-Time American Sign Language Translation Using the Leap Motion and Facial Landmarks. The College of New Jersey.