FIU | FLORIDA INTERNATIONAL UNIVERSITY

# ASL 3D GAME

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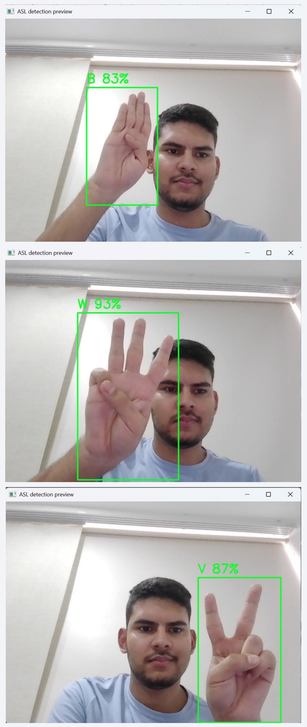
## Problem

- Learning American Sign Language can be difficult for beginners because traditional resources often lack real-time, interactive practice.
- Students need immediate feedback to know whether they are performing hand gestures correctly.
- Existing learning methods may require an instructor, scheduled classes, or repetitive video-based study, which can limit accessibility and engagement.
- A more interactive and accessible solution can help users practice ASL gestures independently while making the learning process more engaging.

## Our Solution

- We developed an interactive 3D game in Unity where users explore a virtual environment and approach different ASL learning activities.
- Each activity presents a letter, number, or sign for the user to perform using a webcam.
- A gesture-recognition system analyzes the user's hand sign and provides immediate feedback on whether the gesture is correct.
- The game uses simple first-person controls and object interactions so learners can move naturally between practice stations.
- The Unity gameplay and AI recognition components were designed separately, making the system easier to test, maintain, and improve.
- The game combines learning with exploration and immediate feedback to make ASL practice more engaging and less repetitive.

## Demo & Screenshots



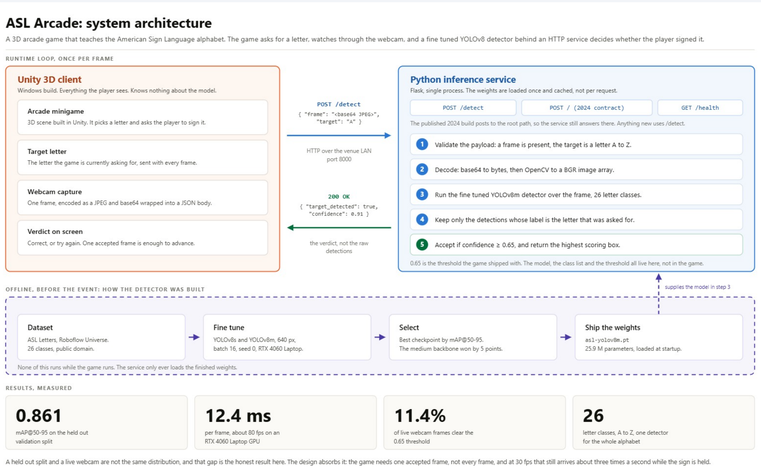

## Engineering Process (SO6)

- ❑ **Planning & Analysis:** We identified the needs of ASL beginners and defined the core features, including movement, interaction, webcam use, gesture recognition, and feedback.
- ❑ **Design:** We created a modular architecture that separates the Unity game, minigame interface, and AI recognition system.
- ❑ **Implementation:** We developed the first-person controller, interaction system, user interface, practice activities, and camera integration in iterative sprints.
- ❑ **Key Decisions:** We prioritized simple controls, immediate feedback, reusable scripts, and independent development of the gameplay and recognition components.
- ❑ **Testing:** We evaluated player movement, interaction prompts, minigame controls, camera connectivity, and correct communication between system components.
- ❑ **Refinement:** Sprint reviews, retrospectives, and user-story testing were used to identify issues and improve functionality throughout development.

## Stakeholders & Requirements

- **Primary Stakeholders:** ASL beginners and students who want an interactive way to practice signs independently.
- **Secondary Stakeholders:** ASL instructors, schools, and future development teams that may use or improve the system.
- **User Needs:** Learners need clear instructions, simple navigation, repeated practice, and immediate feedback on their gestures.
- **Functional Requirements:** The system must support first-person movement, object interaction, webcam input, randomized practice activities, gesture evaluation, and answer display.
- **Non-Functional Requirements:** The game should be easy to use, responsive, modular, maintainable, and reliable during camera-based activities.
- **Accessibility Goal:** The interface should use clear text, simple controls, and understandable feedback for users with different levels of technical experience.

## Architecture




## Results & Evaluation

- **Model Accuracy:** The ASL detector achieved **0.861 mAP@50–95** on the held-out validation dataset.
- **Recognition Coverage:** The model was trained to recognize **26 ASL alphabet classes, A–Z**.
- **Inference Speed:** Detection took approximately **12.4 ms per frame**, equivalent to about **80 FPS** on an RTX 4060 laptop GPU.
- **Live Webcam Testing:** About **11.4% of webcam frames** exceeded the system's **0.65 confidence threshold**.
- **Evaluation Method:** The team tested the trained model using both a validation dataset and live webcam input under real operating conditions.
- **Headline Result:** Although live-camera performance was lower than validation performance, the system only requires one accepted frame, allowing signs to be detected reliably while the user holds the gesture.

## What's Next

- Expand recognition beyond the ASL alphabet to include **numbers, words, and common phrases**.
- Improve the gesture-recognition model using a **larger and more diverse training dataset**.
- Increase reliability across different users, lighting conditions, backgrounds, hand sizes, and camera positions.
- Add structured lessons, difficulty levels, scores, and progress tracking to support long-term learning.
- Improve the 3D environment with additional practice stations, animations, sound, and accessibility options.
- Conduct formal user testing with ASL learners and instructors to evaluate usability, engagement, and educational effectiveness.

## Acknowledgments

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- We also acknowledge **Franco Silvestri** and **Daniel Herrera** for their contributions to the ASL gesture-recognition system, game development, integration, and testing.
- Special thanks to the **KFSCIS Capstone Program and Prof. Masoud Sadjadi** for their guidance and support throughout the project.