SIGN LANGUAGE DETECTION SYSTEM

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Problem Domain

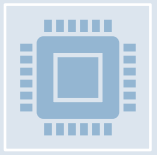
Communication barriers exist for sign language users, especially when interacting with non-signers.

Sign language is critical for millions but lacks seamless translation tech in everyday settings.

Current solutions face issues of cost, complexity, and usability.

Current Industry Practices & Challenges

Sensor-based gloves offer accurate gesture recognition but are expensive and restrict user mobility.



Vision-based software systems use cameras with computer vision algorithms, mostly on powerful PCs.

- Challenges:
  - High computational demand limits use on embedded/low-power devices.
  - Latency and real-time responsiveness issues.
  - Cost and portability concerns for end-users.

Opportunity for Embedded Systems

Embedded devices like Raspberry Pi offer affordable, portable computing power.

Potential to develop compact, low-cost, real-time gesture recognition prototypes.

Can enhance accessibility for sign language users with minimal hardware.

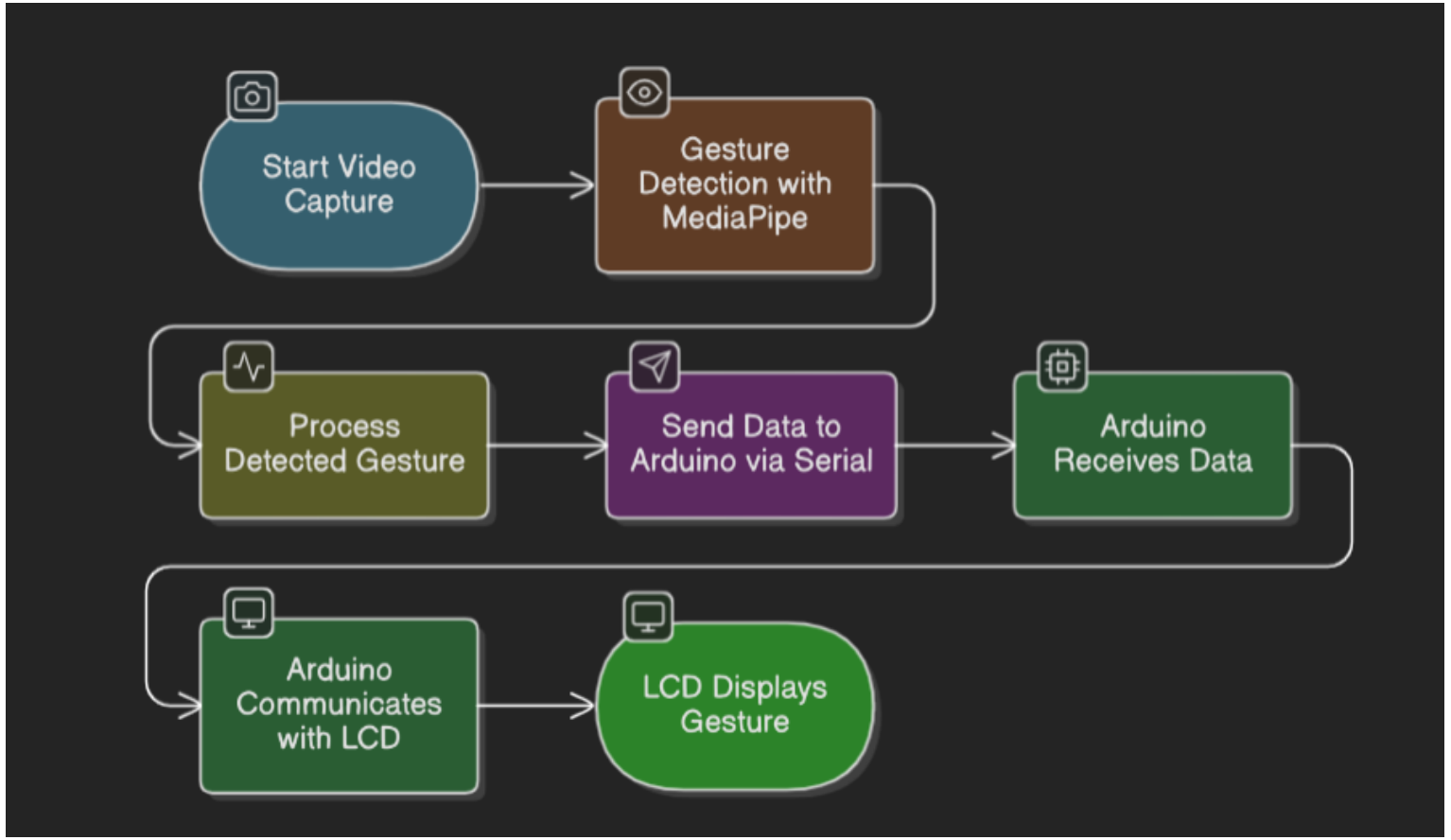
Opportunity to improve latency, reliability, and user-friendliness via optimized embedded design.

Proposed Solution Overview

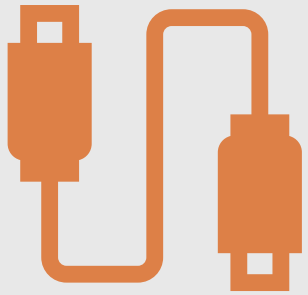
- Design a prototype combining:
  - Raspberry Pi 4 as vision processing unit with camera input.
  - Arduino Nano 33 IoT for gesture display control.
  - 16x2 I2C LCD for simple visual feedback of recognized gestures.
- Use MediaPipe library on Raspberry Pi for real-time hand landmark and gesture detection.
- Communication via USB Serial protocol between Raspberry Pi and Arduino.
- I2C protocol for Arduino to communicate with LCD.

Main Components & Interconnections

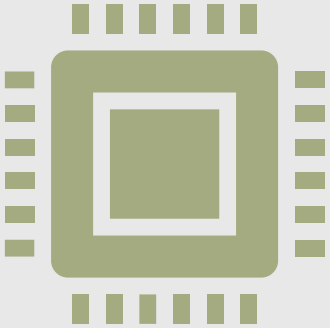
- Raspberry Pi 4 + Raspberry Pi Camera Module: captures and processes hand gestures.
- USB-A to micro-USB cable: connects Raspberry Pi to Arduino Nano 33 IoT.
- Arduino Nano: receives gesture data via serial and controls the LCD.
- 16x2 I2C LCD: displays recognized gesture to user.



Communication Protocols



USB Serial Communication (9600 baud rate) for sending recognized gesture data from Raspberry Pi to Arduino.



I2C Protocol for communication between Arduino and LCD driver for display updates.

Potential User Interface

SIMPLE 16X2 LCD SCREEN DISPLAYING TEXT OF RECOGNIZED GESTURE IN REAL-TIME.

USER-FRIENDLY, MINIMALISTIC INTERFACE ENABLING QUICK UNDERSTANDING.

PORTABLE AND LOW-COST SYSTEM SUITABLE FOR EVERYDAY USE.

Summary

- Problem: Communication barriers exist for sign language users due to limited accessible real-time translation solutions. Current technologies are often expensive or impractical for everyday use.
- Opportunity: Embedded systems like Raspberry Pi and Arduino present a low-cost, portable way to bring real-time gesture recognition to assist communication.
- Proposed Solution: Develop an embedded prototype using:
    - Raspberry Pi with camera for vision-based hand gesture detection (MediaPipe).
    - Arduino Nano controlling an LCD to display recognized gestures live.
    - Communication via USB Serial and I2C protocols.
- Impact: This project aims to create an affordable assistive device that improves interaction for sign language users, sets a foundation for advanced embedded vision applications, and highlights critical design considerations for real-time, low-latency systems.