Embedding Intelligence

Teaching Modern AI Implementation in a Raspberry Pi–Centric Lab Course

Yue Cao and Jiamin Zhao,

Syracuse University, Dept. of Electrical Engineering and Computer Science

Course Context

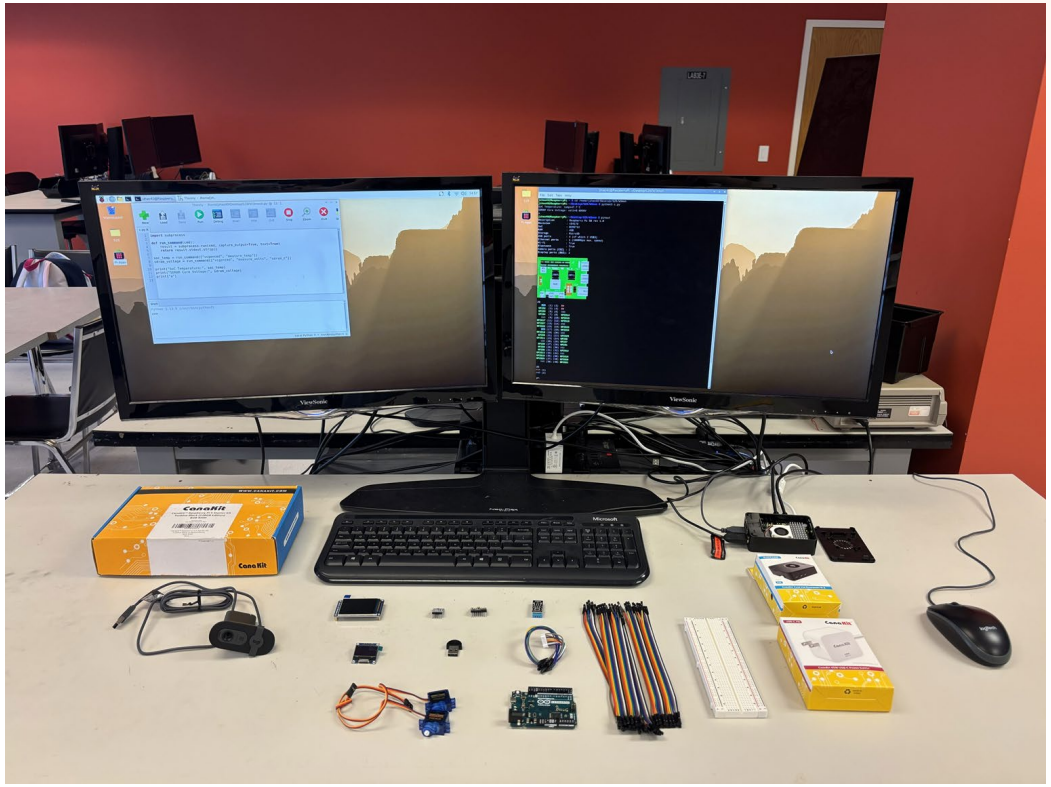
Computer Engineering
CSE 398 Embedded & Mobile Systems Lab

- **Required** 3-credit **Junior-level lab** at Syracuse University.
- **Focus:**

  Design and prototype system-level project

  with the Raspberry Pi platform.

  Emphasize system-level hardware-software integration.



lab workstation and hardware components

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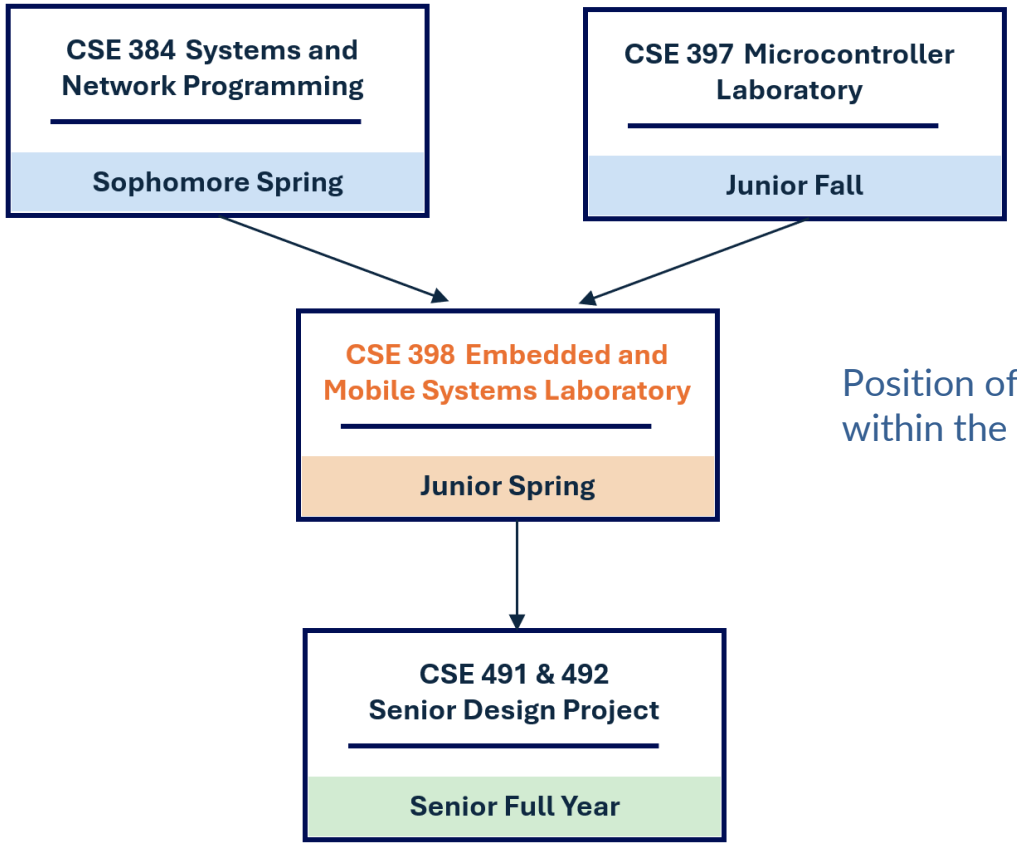

Position of this lab course
within the Computer Engineering curriculum

Two-Phase Lab Structure

Phase I: Regular Labs

The first 8 weeks focus on highly structured laboratory sessions.

Two 3-hour lab sessions per week.

Phase II: Custom Project

The final 5-6 weeks are for an open-ended design project.

Student groups propose and implement their own projects.

Phase I: Regular Lab Session Topic

Foundational Sessions

Newly Added AI Sessions

Session	Topic	Description
1	**Raspberry Pi Setup**	Install Raspberry Pi OS and essential development software
2	**Raspberry Pi OS**	Familiar with command-line tools and Python IDE
3	**GPIO**	LED and pushbutton interfacing using the GPIO Zero library
4	**I²C**	SSD1306 OLED display interfacing using I²C
5	**SPI**	Waveshare LCD display interfacing using SPI
6	**Network Socket**	Via three different methods: http.server, Python socket, and ZeroMQ
7	**Arduino Sensor**	Sensor → Arduino → Raspberry Pi integration
8	**Web-Controlled Servos**	Raspberry Pi → Arduino → motor integration, basic Flask web interface
9	**Web Weather Monitor**	Multi-sensor integration with Flask web interface, developed with AI-assisted programming
10	**Speech Recognition**	Use Faster-Whisper with microphone input
11	**Large Language Models**	Domain-specific application of LLMs in circuit analysis
12	**Computer Vision I**	YOLO26 visual servoing
13	**Computer Vision II**	Deep learning Workflow, MobileNetV3 deployment
14	**MediaPipe Edge AI**	Deployment of Google MediaPipe use cases

Regular Lab Session Example 1

Faster-Whisper Speech Recognition

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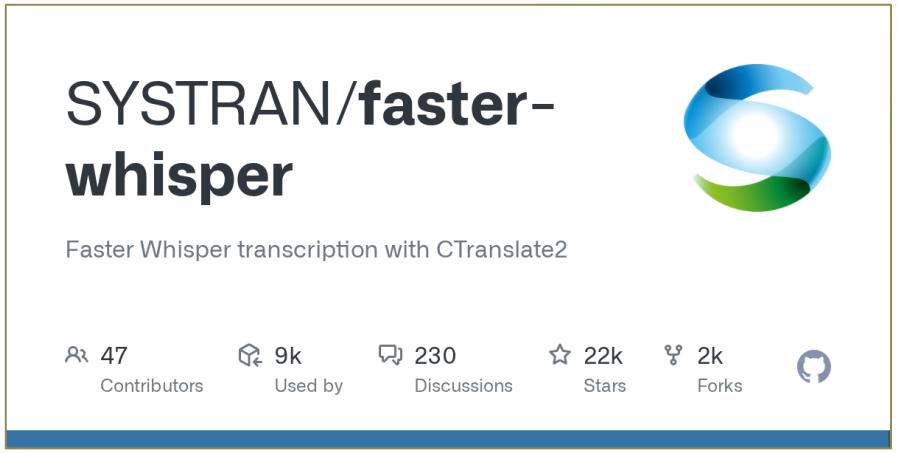
- Configure Audio settings on Raspberry Pi
- Install and test **Faster-Whisper** on Raspberry Pi
- Exam the resource usage (CPU, RAM) of different models of Faster-Whisper
- Design a voice-based food menu ordering system that runs locally on Raspberry Pi



Regular Lab Session Example 2

MobileNet Real-Time Image Classification

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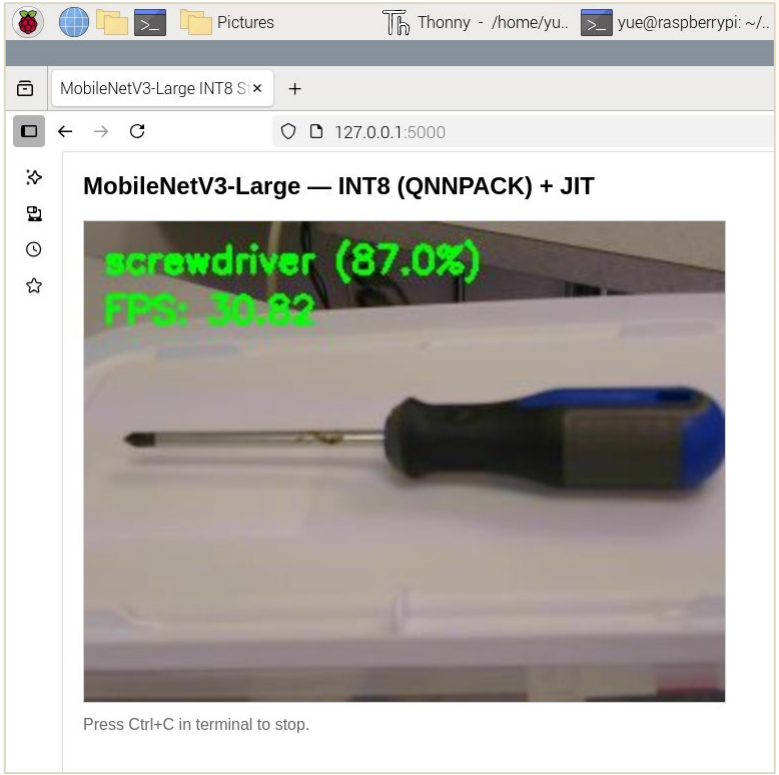
- Use pre-trained **MobileNetV3-Large** via PyTorch
- Understand the pre-trained dataset (ImageNet-1K)
- Configure run setting for edge devices (CPU thread, int8 quantization, QNNPACK for ARM core)
- Observe different real-time performance under different CPU threads (max 4 cores for Raspberry Pi)



Regular Lab Session Example 3

MediaPipe Edge AI

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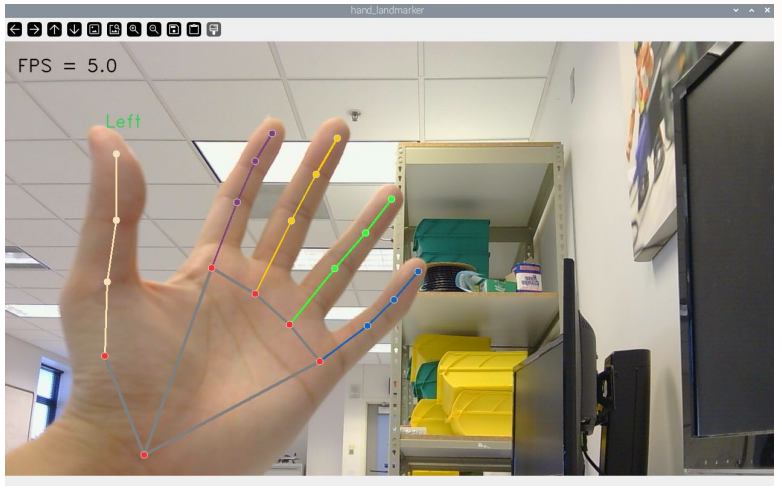
- Try Raspberry Pi examples from **MediaPipe Studio**,

  Such as Gesture Recognize, HandLand Mark, Face Detect, Pose Landmark, …

- Hardware–Software Integration with MediaPipe.

  Extend one MediaPipe use case and connect the AI detection result to a hardware output on Raspberry Pi (LED, Motor, small display, …)



Core Idea

Hardware-Software Integration

A foundational competency in Computer Engineering

AI on Edge Device

A distinctive skill for Computer Engineering students in modern AI era

Phase II: Custom Project (Demo Day)

Computer Engineering
Students Project
at the end of Junior Year

Phase II: Custom Project (Example)

SYRACUSE UNIVERSITY ENGINEERING & COMPUTER SCIENCE

BarBack

Manling Yu, Nathan Czarnecki, and Andrew Snow

DISCLAIMER: For the purposes of testing and legal reasons, all liquids in this presentation are dyed water.

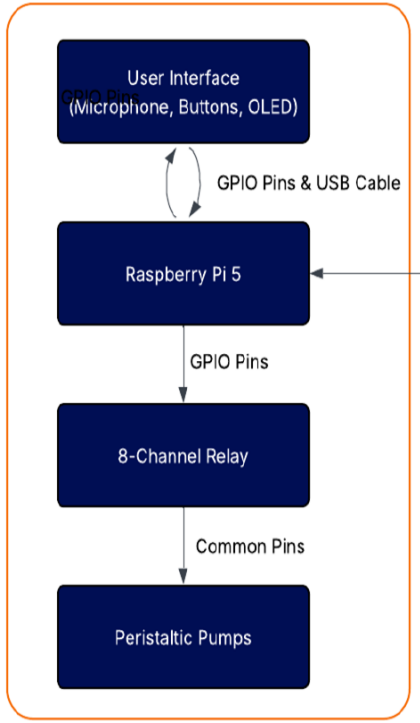
Description:

This project features an automated bartender that mixes and serves custom drinks based on user input. Powered by a Raspberry Pi 5, it controls peristaltic pumps and valves for precise dispensing. Users interact through voice commands, an OLED display, and physical buttons, creating a smooth and hands-free experience.

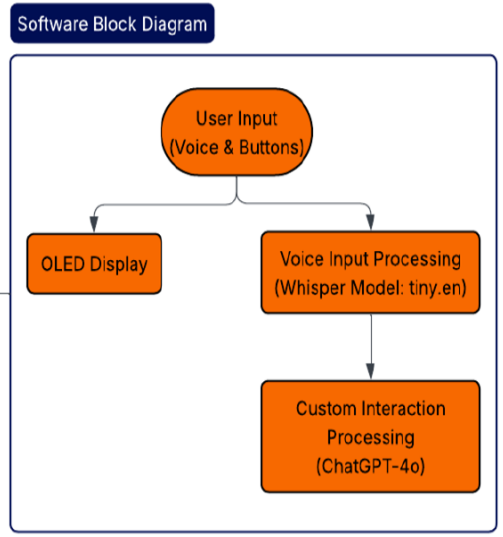
Materials:

- Raspberry Pi 5
- 8-channel Relay
- Peristaltic Pumps
- OLED Display
- Microphone
- 12V Power Source
- 5V Regulator
- Buttons
- LEDs

Hardware Block Diagram



Software Block Diagram



How does it work?

Simply lean in and say “wake up” to make the AI start listening. Scroll through the list of provided drinks, and then tell the BarBack if you want any adjustments to the drink (less coke, no rum, double soda, etc.) and then press the green button to confirm your change, and once more to have the BarBack pour your drink!

Key Tech:

- Real-time OLED Display
- Speech-to-Text Transcription (Whisper API - tiny.en)
- Custom Interaction with ChatGPT-4o
- Pump Control via Raspberry Pi & Relay

Thanks

Course Materials are open-access on my GitHub Repo:

https://github.com/BotYue

Yue Cao
Assistant Teaching Prof
Syracuse EECS

Jiamin Zhao
Graduate TA
Syracuse EECS