CLARE: Lab Availability Tracker

Senior Design December 2023 Team 04

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IOWA STATE UNIVERSITY

Problem Statement

- Many engineering courses have assignments that require use of computer labs

- Labs have limited space and equipment

- Many labs do not have a way to check availability before going there

- Lab schedules are not readily available remotely

- CLARE aims to solve these issues by counting the amount of people in the lab rooms and making it accessible

Requirements

- Able to achieve 90% accurate headcount

- Include all labs in Coover Hall

- Create a website for displaying lab statistics and schedule information

    - Will display amount of people in each lab room

    - Also displays schedule for each lab room

    - Canvas integration for website will also be provided

- Cost less than Iowa State's existing solutions

Existing Solutions

- Chair occupancy sensors

- Room displays

  - See the lab schedule

- Desk panels

  - Manually check in and out desk spaces

- LabStats

 - Shows the number of desktops that have users logged in

Lab Availability

https://it.engineering.iastate.edu/labs/

Department	Lab	Availability	Open	Total Workstations	In Use	OS	Info
MSE	Hoover 3337	Not Busy		42	13	⊞	
ECpE	Coover 1318	Not Too Busy		25	11	⊞	
ECpE	Coover 2041	Busy		16	11	⊞	
ECpE	Coover 1313 TLA	Not Too Busy		26	10	⊞	
ECpE	Coover 2048	Not Too Busy		25	9	⊞	
ME	Black Engineering - Heat Transfer	Full	Open Now	8	8	⊞	
ECpE	Coover 2042	Not Busy		24	6	⊞	
ECpE	Coover 1313 Workbenches	Not Too Busy		12	6	⊞	
ME	Black Engineering - Fluids Lab	Full	Open Now	6	6	⊞	

Solution Overview

- Collect lab usage data
  - Cameras and ML model
  - Computer usage
- Collect lab schedule data from ISU
- Combine data and display intuitively on website
- Integrate website with Canvas
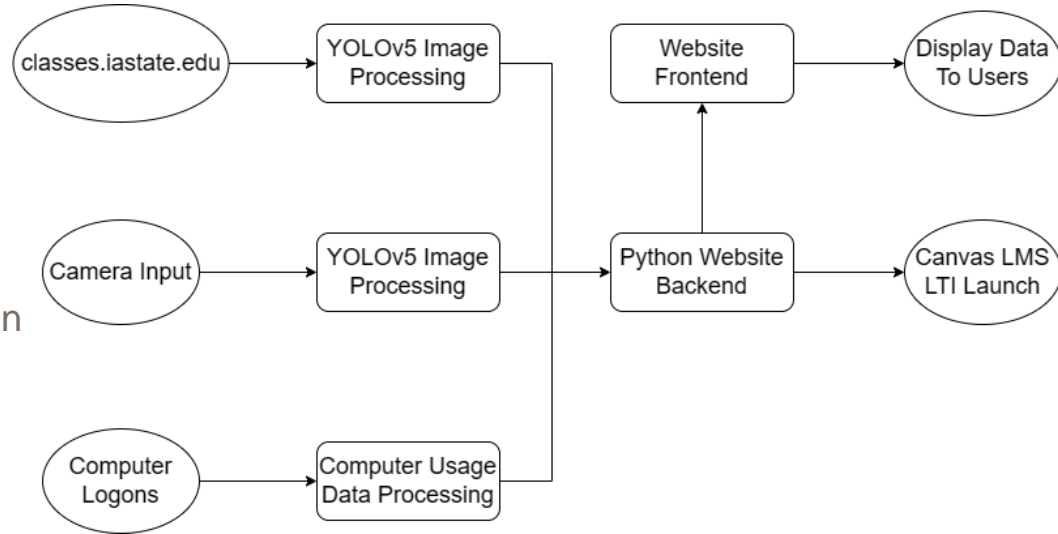
Comparison to LabStats

LabStats

- Does not track Linux computers
- Only counts people logged into a desktop
- Expensive (list price $14 per computer annually)
- Does not display lab schedules

CLARE: Lab Availability Tracker

- Works in a wide variety of rooms
- Counts people in seats regardless of equipment usage
- Relatively low cost
- Displays lab schedules

Risks and Mitigations

- Risks and Mitigations:
  - Machine Learning accuracy is below our requirements
    - Supplement image processing data with computer usage data
  - Concerns over privacy stemming from cameras
    - Only store images temporarily and delete them afterward
  - Security issues may leak sensitive data from users
   - Employ basic encryption

Project Cost

- Cameras for computer vision implementation
  - $500 for the camera
  - As much as $18.78 per year for each camera in energy costs
- Computer to run computer vision system; YOLOv5 requires an Nvidia GPU
  - $500 for an RTX 3070
- Server for website
- ETG time to setup cameras

Milestones

- Website displays current lab usage at an accuracy of 90%

- Website loads within three seconds of user access

- Number of labs tracked

    - Part 1: Capable of tracking one lab in Coover Hall

    - Part 2: Capable of tracking all labs in Coover Hall

- Website integrated into Canvas, with ability to add it to specific courses

- Website displays accurate lab schedules for labs which it supports

- Computer tracking software developed removes need for LabStats

Technical Overview
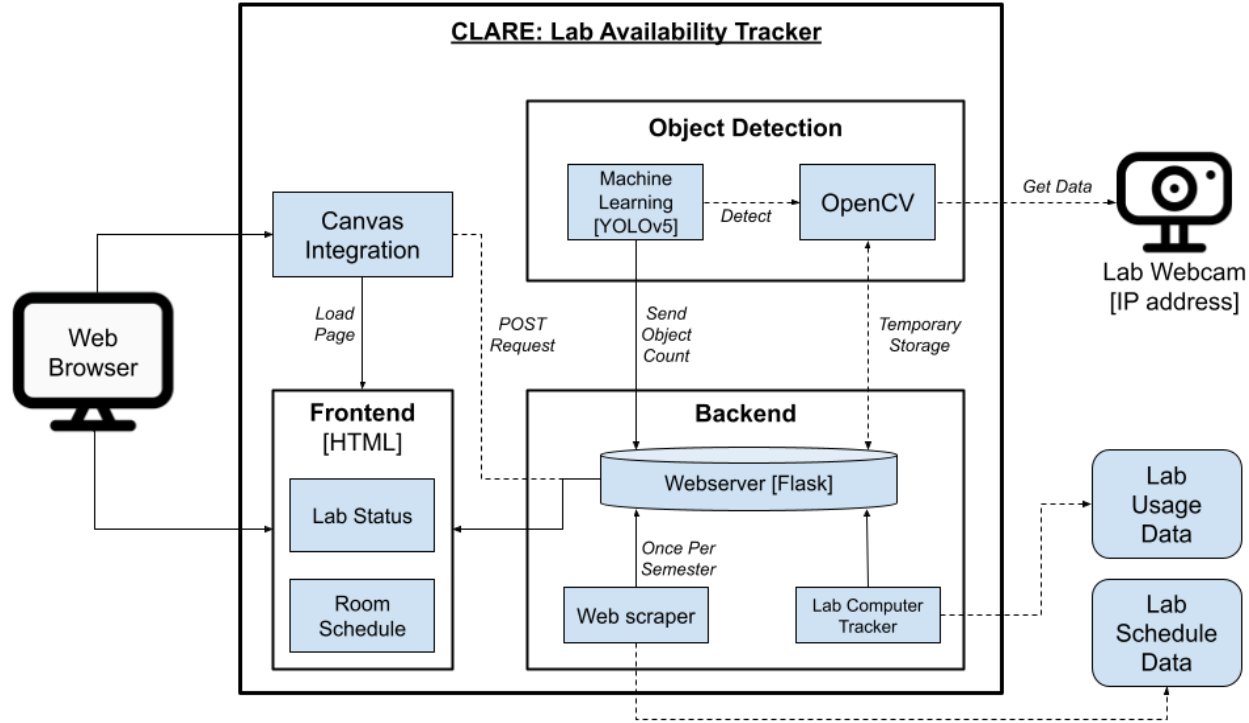
YOLOv5 (You Only Look Once)

- Built on PyTorch framework

- Object detection models

  - Pretrained on COCO dataset

  - Investigating other datasets
    (e.g., MIT Indoor Scenes)

- Primary tool for determining lab
  occupancy
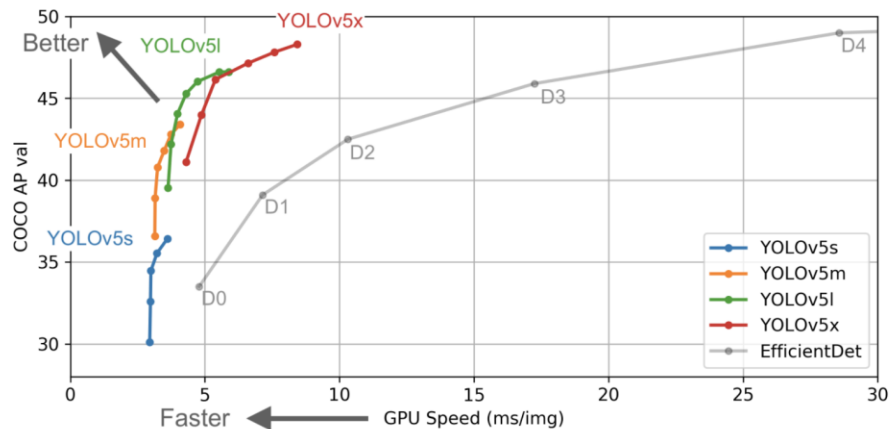
Graph taken from YOLOv5 website

Current Camera Progress

- An IP camera is installed in the senior design lab by ETG
- Python OpenCV code to get images from the camera
- Python code to run the YOLOv5 image recognition model on the images
- Python OpenCV code to draw bounding boxes on results which are people and save the images
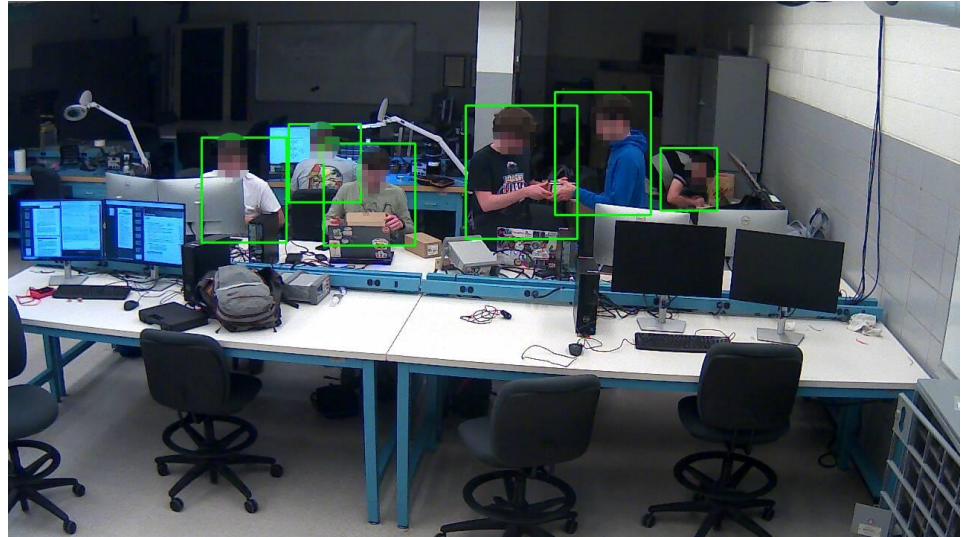
Current example output from the code surrounding the camera (faces blurred for privacy)

LabStats Usage Plan

Supplement

Supplement our lab usage data using LabStats

Improve our lab usage accuracy by adjusting the camera to match LabStats

Used during development

Reduce

Reduce dependence on LabStats

Check out lab usage data in production compared to LabStats

Used for verification

Remove

Remove LabStats from the project

Use our project without LabStats once it has high accuracy

Potential to save the College of Engineering funds by not paying for LabStats

Canvas Integration

- Instructors will be able to easily add CLARE to their course
- Students can then see CLARE as a navigation link
- Canvas authenticates website and sends basic context info via JSON web token
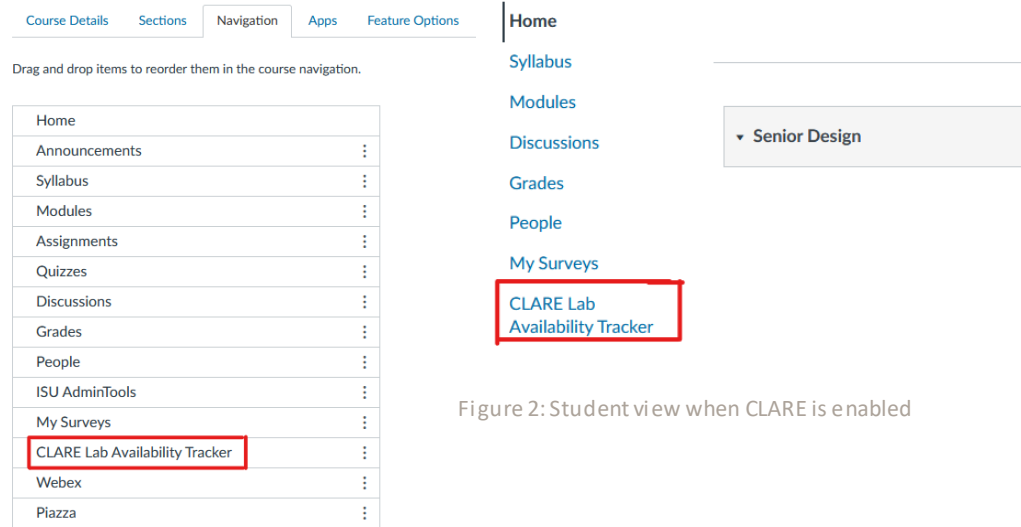

Figure 1: Instructor view when enabling CLARE

Figure 2: Student view when CLARE is enabled

Frontend

- Main page will display a list of lab rooms and their occupancy

- Users will be able to click on a room to see the scheduled labs

Department	Lab	Availability	Open	Total Workstations	In Use	OS	Info
ABE	1311 Elings Hall	Not Busy		6	0	⊞	
ABE	su0214	Not Busy		47	3	⊞	
ABE	2217 Sukup Hall	Not Busy		52	9	⊞	
ABE	su4209	Not Busy		36	0	⊞	
ABE	su4219	Not Busy		24	1	⊞	
ABE	su4222	Not Busy		22	7	⊞	

	06:00	07:00	08:00	09:00	10:00	11:00	12:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00
Mon						CL ST 373		CPR E 511	CPR E 414		CPR E 414					
Tue						COM S 342			PHYS 232L							
Wed					COM S 342	CL ST 373		CPR E 511			CPR E 414					
Thur						COM S 342			CPR E 492							
Fri						CL ST 373		CPR E 511								
Sat																

Backend

- Backend will handle POST requests from the web camera and GET requests from the website

- Considering Python web framework Flask because it doesn't have a database abstraction layer

  - The only persistent data in our system is the scheduled lab dates and times

  - Flask, OpenCV, and YOLOv5 each support Python allowing the machine learning algorithm and web server to be in the same software module

Test Plan

- Automated tests

    - Will use a GitLab pipeline for high reliability features

    - Backend API functions, YOLOv5 script on test images

- Feature tests will be done before merging changes

    - Document testing and keep a record of process

    - Perform any existing tests relevant to changes + automated tests

- Regularly perform system tests

    - Manually test the CLARE website and displayed data as a whole

Project Status

Several prototype/POC components have been developed

- **Website**

    - Retrieving data from LabStats

    - Coover Hall lab schedule web scraper

        - Matches room numbers to class schedules

- **Object detection**

    - Camera in Senior Design Lab

    - Script to remotely get occupancy

Task	Team members	Work Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
YOLOv5															
Narrow down dataset choices	Frank, Evan	■	■												
Test YOLOv5 accuracy with different options	Frank, Evan		■	■											
Use additional data to track lab usage	Frank, Evan				■	■									
Expand YOLOv5 usage to all Coover Hall labs	Frank, Evan						■	■	■						
Use additional data in all Coover Hall labs	Frank, Evan								■	■	■	■			
Ensure data meets accuracy requirements	Frank, Evan									■	■	■	■	■	■
Website															
Design frontend webpages	Tyler	■	■	■	■	■	■	■							
Set up backend API	Joel, Jorge	■	■	■	■	■									
Implement Canvas integration	Jorge						■	■	■						
Send YOLOv5 data to backend	Joel, Evan					■	■	■							
Integrate frontend and backend	Joel, Jorge, Tyler								■	■	■	■			
Ensure Canvas integration is complete	Joel, Jorge, Tyler												■	■	
Develop computer activity software	Frank, Evan, Joel												■	■	■

Conclusion

- Lab availability tracker

  - Coverage for every lab in Coover Hall

  - Using object detection and computer activity data

- CLARE website

  - Standard page and Canvas integration

  - Lab status

  - Lab schedule