CLARE: Lab Availability Tracker

Senior Design December 2023 Team 04

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IOWA STATE UNIVERSITY

Overview

- Problem Statement
- Existing Solution
- Our Solution
  - Schedule
  - Technical Details
  - Testing
- Challenges & Conclusion

Problem Statement

- Labs have limited space and equipment
- Students lack a way to check how busy labs are remotely
- No convenient way to check lab schedules
- Students prefer to schedule lab work
- CLARE solves this by providing live data:
  - Current lab occupancy
  - Lab schedules
  - Available workstations

Example of a busy lab room on campus

LabStats

- Provides
  - Current desktops logged in
- Not supported on Linux
- Expensive
  - List price: $14/computer/yr
- Not used often by students

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

Lab Availability

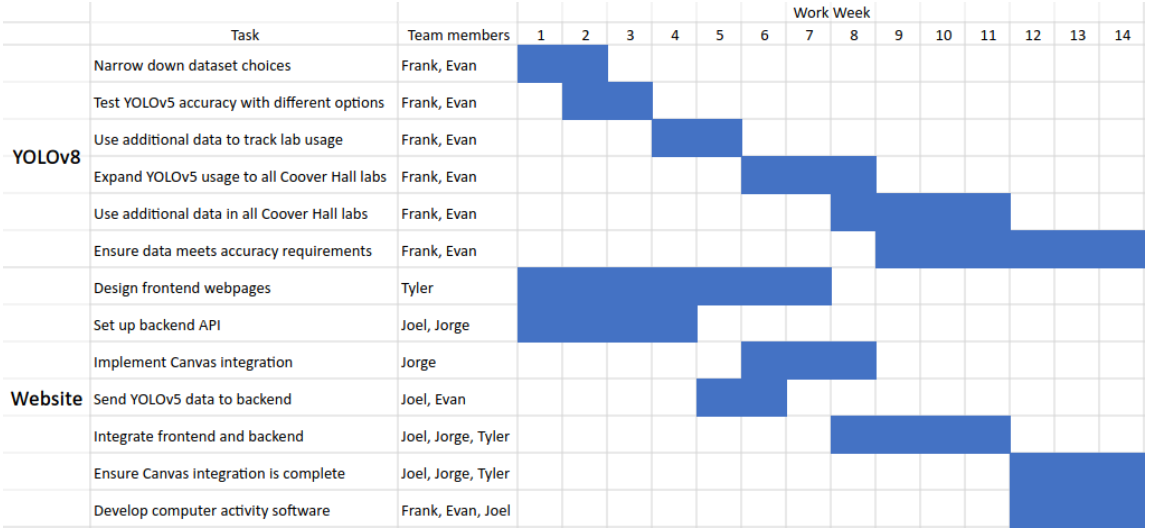
Department	Lab	Availability	Open	Total Workstations	In Use	OS	Info
MSE	Hoover 3337	Not Busy		42	13		
ECpE	Coover 1318	Not Too Busy		25	11		
ECpE	Coover 2041	Busy		16	11		
ECpE	Coover 1313 TLA	Not Too Busy		26	10		
ECpE	Coover 2048	Not Too Busy		25	9		
ME	Black Engineering - Heat Transfer	Full	Open Now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

Requirements

- Able to achieve 90% accurate headcount
- Create a website for displaying lab statistics and schedule information
  - Display the amount of people in each lab room
  - Display the schedule for each lab room
  - Provide Canvas integration for the website
- Cost less than Iowa State's existing solution
  - No yearly subscription

Schedule

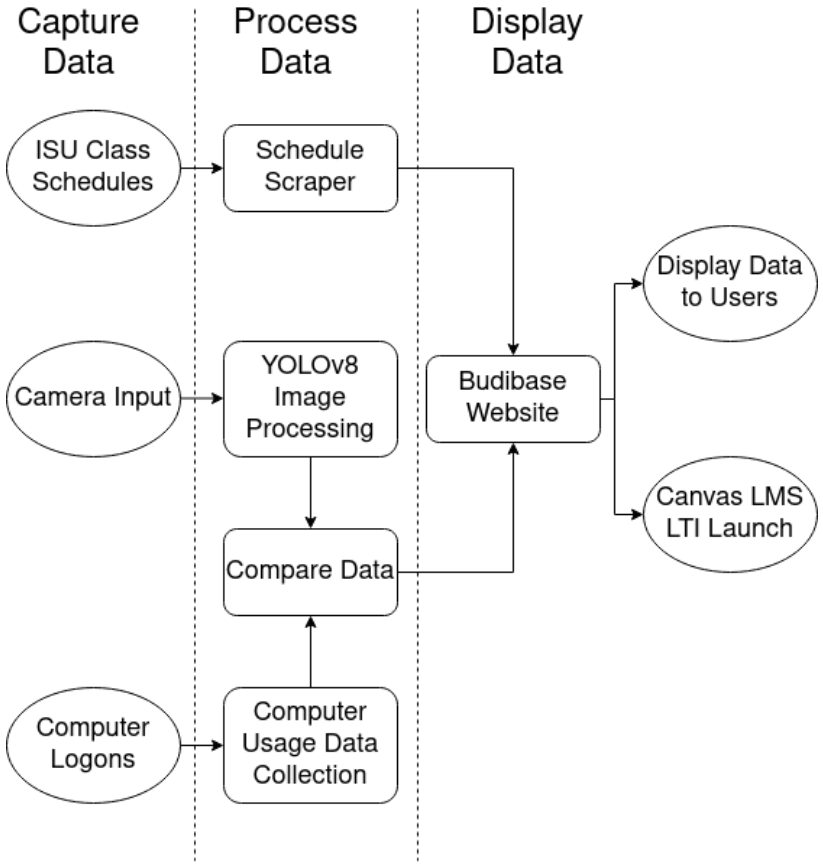
- Project scope changed between semesters during Agile process
  - Prototype created, not expanded to more labs
- Computer activity software expanded to be a bigger focus
- BudiBase decreased frontend design time needed
- Canvas integration delayed longer than expected



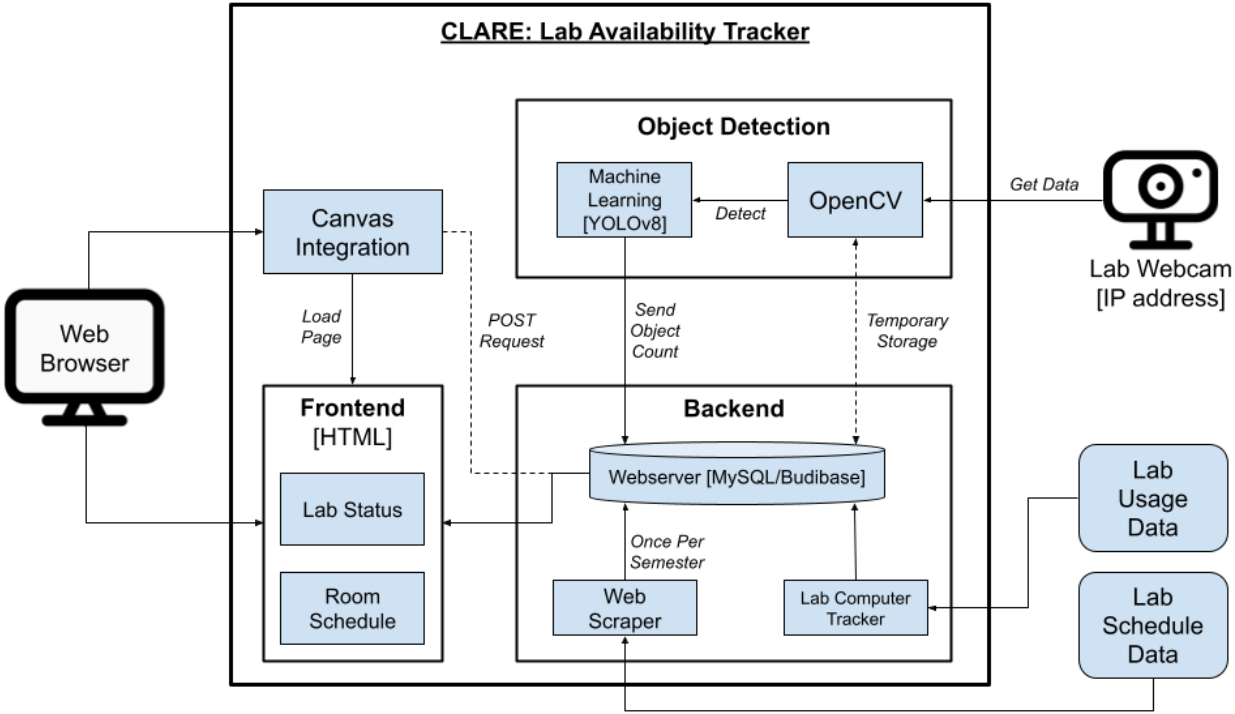
Gantt chart created at the end of last semester

Solution Overview

- Collect lab usage data
  - Camera
  - Track Logons
  - Lab Schedules
- Process lab usage data
  - Perform Image Processing
  - Combine lab usage and computer vision (CV) data
- Display data
  - CLARE website
  - Canvas integration



Technical Overview

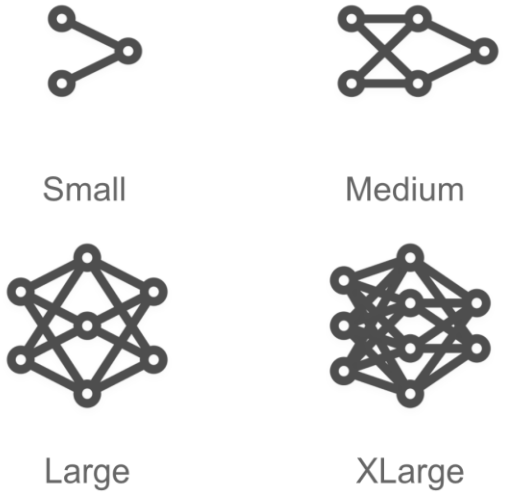


Project Cost

- Cameras for computer vision implementation
  - Roughly $70 for the camera
  - Upper limit of $18.78 per year for each camera in energy costs
    - Max power of 30W over ethernet and $0.14/kWh energy rate
- Graphics card compatible with computer vision system
  - YOLOv8 requires an Nvidia GPU
  - $500 for an RTX 3070
- Server for the website and processing camera images
- Labor costs to install the cameras

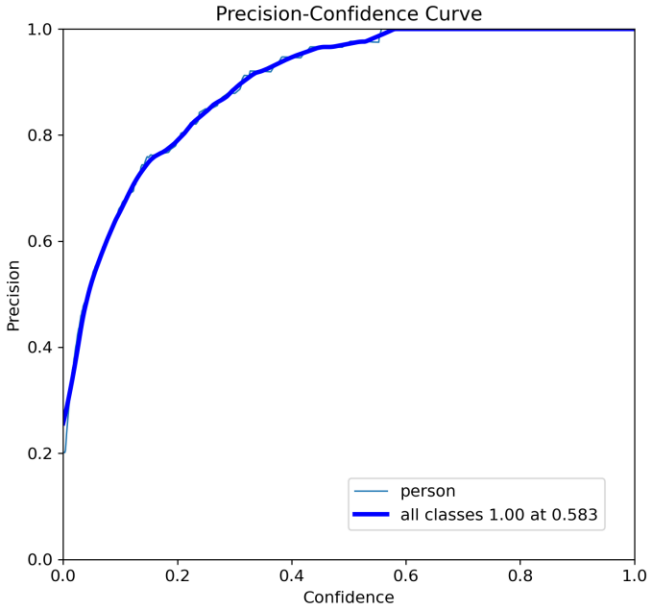
YOLOv8 (You Only Look Once)

- Object detection framework
  - Built on PyTorch framework
  - utilizes convolutional neural networks
- Primary tool for determining lab occupancy
- Retrained models on different datasets and compared to default dataset
  - "CrowdHuman" dataset
  - Varied object classes

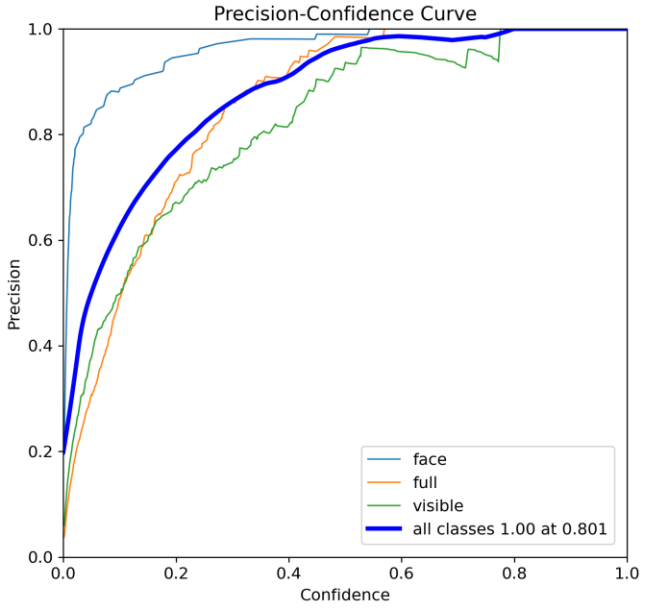


Visual comparison of pretrained YOLO models

COCO vs. CrowdHuman Datasets



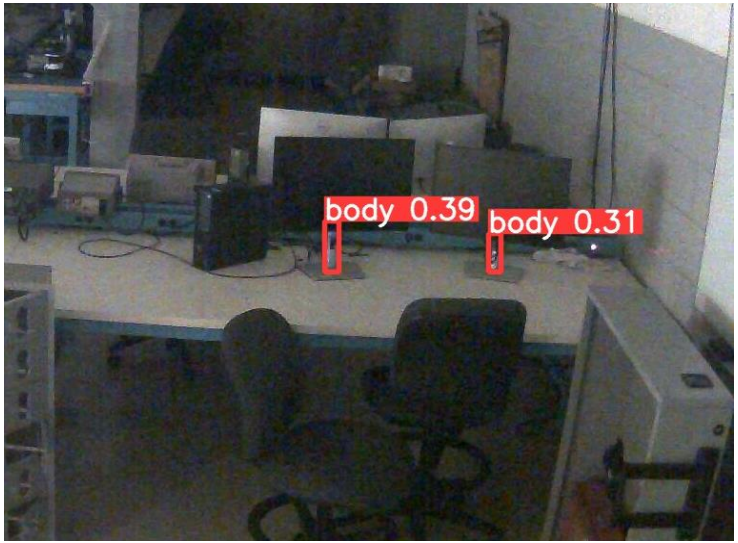
Default COCO dataset



CrowdHuman dataset

Camera Privacy

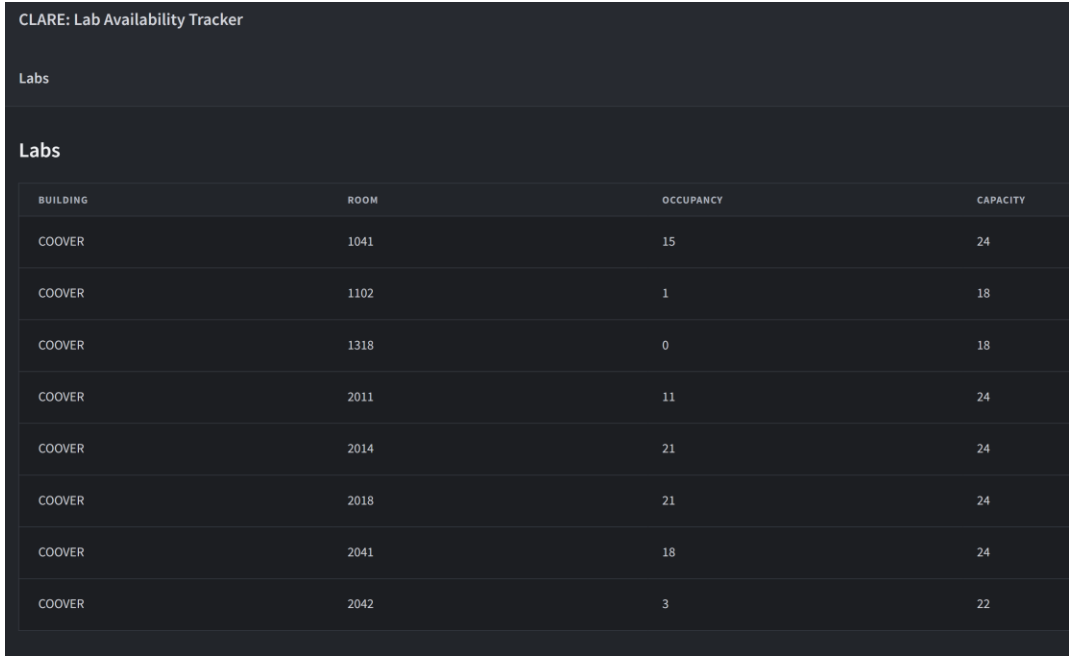
- Images destroyed after processing
- ML model only used to determine occupancy
  - Individuals are not identified
- Distorting images could improve privacy
  - Trained a model using distorted images
  - Detection accuracy decreased
    - Increase in false positives
    - Not viable for current implementation



False positives more likely for certain datasets

Web UI

- Web UI is built using BudiBase
  - Low code website design and database management solution
  - Provides a fast and easy way to create a GUI
  - Flexibility for custom components and queries



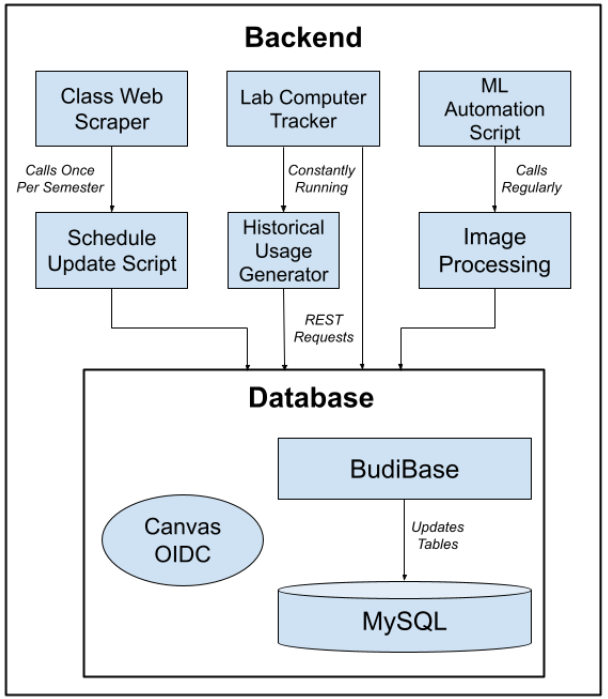
BUILDING	ROOM	OCCUPANCY	CAPACITY
COOVER	1041	15	24
COOVER	1102	1	18
COOVER	1318	0	18
COOVER	2011	11	24
COOVER	2014	21	24
COOVER	2018	21	24
COOVER	2041	18	24
COOVER	2042	3	22

Frontend

- Main page displays an overview of lab rooms and how busy they are
- Each lab has a detailed page with
  - Current occupancy
  - Lab schedule
  - Historical usage
- Schedule is a custom component made with Svelte

Backend

- MySQL database
  - Updated through BudiBase via REST API
- Automated tasks
  - Lab room schedule updater
    - Parses data from ISU's class schedule
    - Updated once a semester
  - Historical usage generator
    - Keeps a rolling average of lab usage
    - Updates with lab occupancy

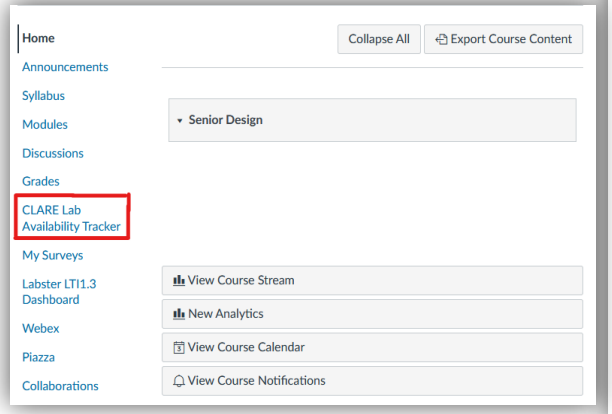


Computer Login Tracking

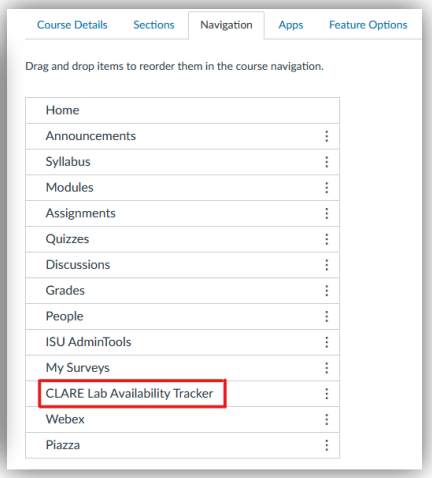
- Computer login tracking is used to supplement computer vision data
- We developed prototype login tracking software for Windows and Linux
  - Linux:
    - Login history is stored in var/log/wtmp by OS
    - inotify provides notifications when file system changes occur
    - A modification to var/log/wtmp implies a login/logout
  - Windows: uses Windows Task Scheduler to track security events
- When a login/logout event occurs, a script runs to update the database

Canvas Integration

- Students can see CLARE as a navigation link
- Instructors can easily add CLARE to their course
- Canvas authenticates website and sends basic course info
- CLARE uses that data to display the appropriate lab room used by the class



Student view when CLARE is enabled



Instructor view when enabling CLARE

Testing

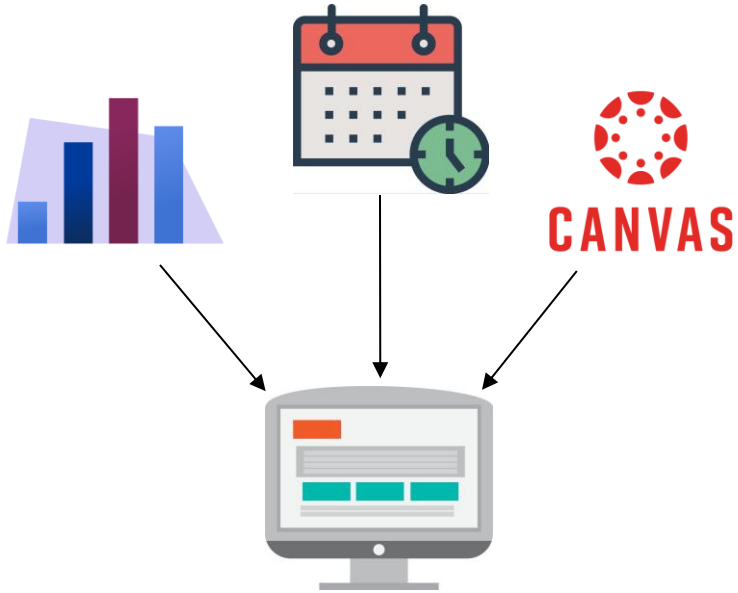
- Unit Testing
  - Test accuracy of YOLOv8 model given an image with a known headcount
  - Test computer usage software performs as expected after a login/logout event
- Integration Testing
  - Test that CV data is consistent between data collected and data stored
  - Test that computer usage data is consistent between data collected and data stored
- System Testing
  - Regular tests to compare real number of people in lab and the displayed number
  - Tests to ensure displayed lab schedules match official ISU schedules

Challenges & Future Work

- Approval process for application to be integrated with Canvas
    - Needs to be reviewed by the ISU LMS Enterprise Team
- Privacy and security is a major concern while using a camera
    - Continue experimenting with image distortion
    - Multiple cameras could mitigate the loss in accuracy
- Expand CLARE to show occupancy for additional labs around campus
- Additional sensors for flexibility

Conclusion

- CLARE is a lab availability tracker
  - Uses object detection and computer activity data
  - Real-time updates for room occupancy
  - Also provides historical occupancy info
- CLARE shows lab room schedules
  - Updated each semester
  - Gives additional context for peak lab times
- CLARE will have Canvas integration
  - Convenient for students
  - Additional feature, website is functional by itself



Thanks for Listening

Questions?