CLARE: Lab Availability Tracker

Senior Design December 2023 Team 04

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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	4
ECpE	Coover 1318		Not Too Busy			25	11	4
ECpE	Coover 2041		Busy			16	11	4
ECpE	Coover 1313 TLA		Not Too Busy			26	10	4
ECpE	Coover 2048		Not Too Busy			25	9	4
ME	Black Engineering - Heat Transfer		Full	Open Nov	v	8	8	4

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

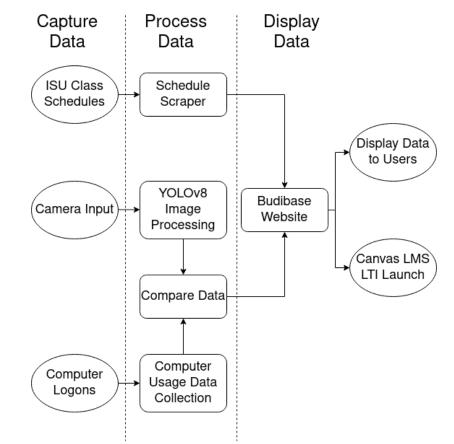
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									Work	Week						
	Task	Team members	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Narrow down dataset choices	Frank, Evan														
	Test YOLOv5 accuracy with different options	Frank, Evan														
YOLOv8	Use additional data to track lab usage	Frank, Evan														
101048	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														
	Design frontend webpages	Tyler														
	Set up backend API	Joel, Jorge														
	Implement Canvas integration	Jorge														
Website	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														

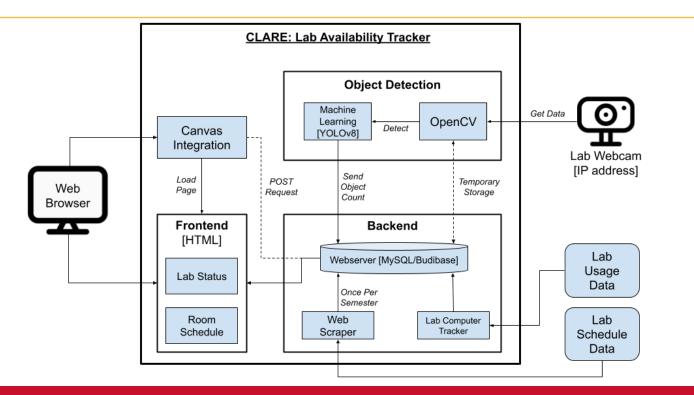
Gantt chart created at the end of last semester

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

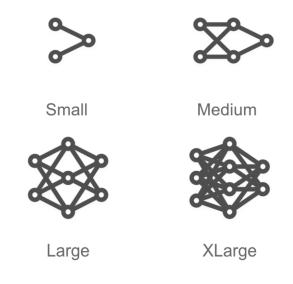


Project Cost

- 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

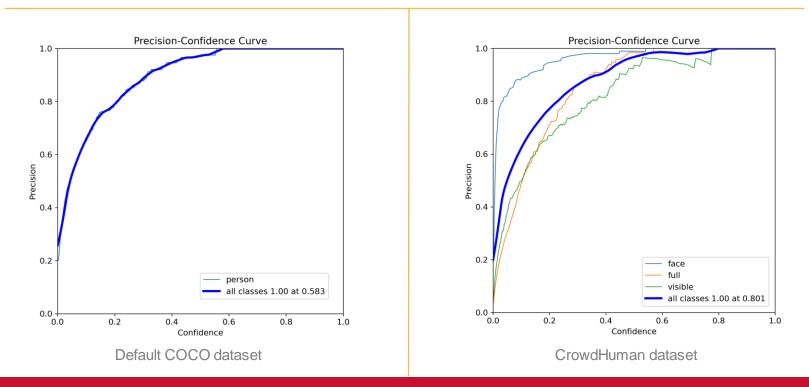
YOLOv8 (You Only Look Once)

- 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



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

CL	ARE: Lab Availability Tracker			
Lal	bs			
La	bs			
	BUILDING	ROOM	OCCUPANCY	CAPACITY
	COOVER	1041		24
	COOVER	1102		18
	COOVER	1318		18
	COOVER	2011		24
	COOVER	2014		24
	COOVER	2018		24
	COOVER	2041		24
	COOVER	2042		22

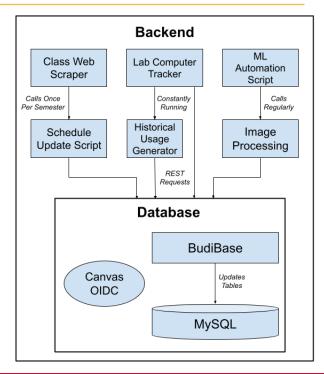
Frontend

- 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

Current usage: 🗄	15/24				
Monday	Tuesd	lay	Wednesday	Thursday	Friday
:00am					
:00am	CYBE 331 Section 2	Sec	tion 1	CYB E 230 Section 1	CYB E 230 Section 2
0:00am	9:00am - 10	0:50am	0am - 10:40am	9:00am - 10:50am	8:50am - 10:40am
1:00am				CYB E 230 Section 3	
2:00am				11:00am - 12:50pm	CPR E 388
:00pm					Section 2 12:05pm - 1:55pm
:00pm	CYB E 230				CYB E 231
:00pm	Section 4 2:10pm - 4:	00pm			Section 3 2:10pm - 4:00pm
:00pm	CYB E 231			CPR E 388	
:00pm	Section 1 4:10pm - 6:	00pm		Section 1 4:10pm - 6:00pm	
:00pm	CYB E 331				
:00pm	Section 3 6:10pm - 8:	00pm			
:00pm	o.ropin-o.				
Tuesday					

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

				Course Details	Sections	Navigation	Apps	Feature Opti		
Home		Collapse All	4 Export Course Content	Drag and drop item	is to reorder th	nem in the cours	e navigatio	n.		
Announcements				Home						
Syllabus				Announceme	ents			:		
Modules	 Senior Design 			Syllabus				÷		
Discussions				Modules				÷		
Grades				Assignments				:		
				Quizzes				:		
CLARE Lab Availability Tracker				Discussions				:		
My Surveys				Grades				÷		
Labster LTI1.3	III View Course Stream			People				1		
Dashboard					ISU AdminTools					
Webex	III New Analytics			My Surveys				÷		
Piazza	S View Course Calendar			CLARE Lab A	vailability Tr	acker		÷		
Collaborations	Q View Course Notifications			Webex				÷		
Collaborations				Piazza				:		

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

- · 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

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• Additional feature, website is functional by itself

Thanks for Listening

Questions?