Bench Organizer

Team 12: Liangcheng Sun & Xiaohu Mu

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Introduction

Our project aims to improve tool tracking and management in workspaces

We redesigned our original vision to simplify hardware and strengthen real-time alerting.

Objective

What problem are we solving?

- Tools are frequently misplaced or left out.

- Manual systems like sign-out sheets are unreliable.

Our goal: build a camera-based, automated tool detection and alert system.

High-Level Requirements

1. Accuracy and Responsiveness

System should recognize ≥ 90% of tools using YOLO

Recognition time < 2 seconds

2. Robustness

Works reliably under different lighting

Can distinguish "place" vs "remove" actions

3. Extended Functionality

Alerts user on unknown tools

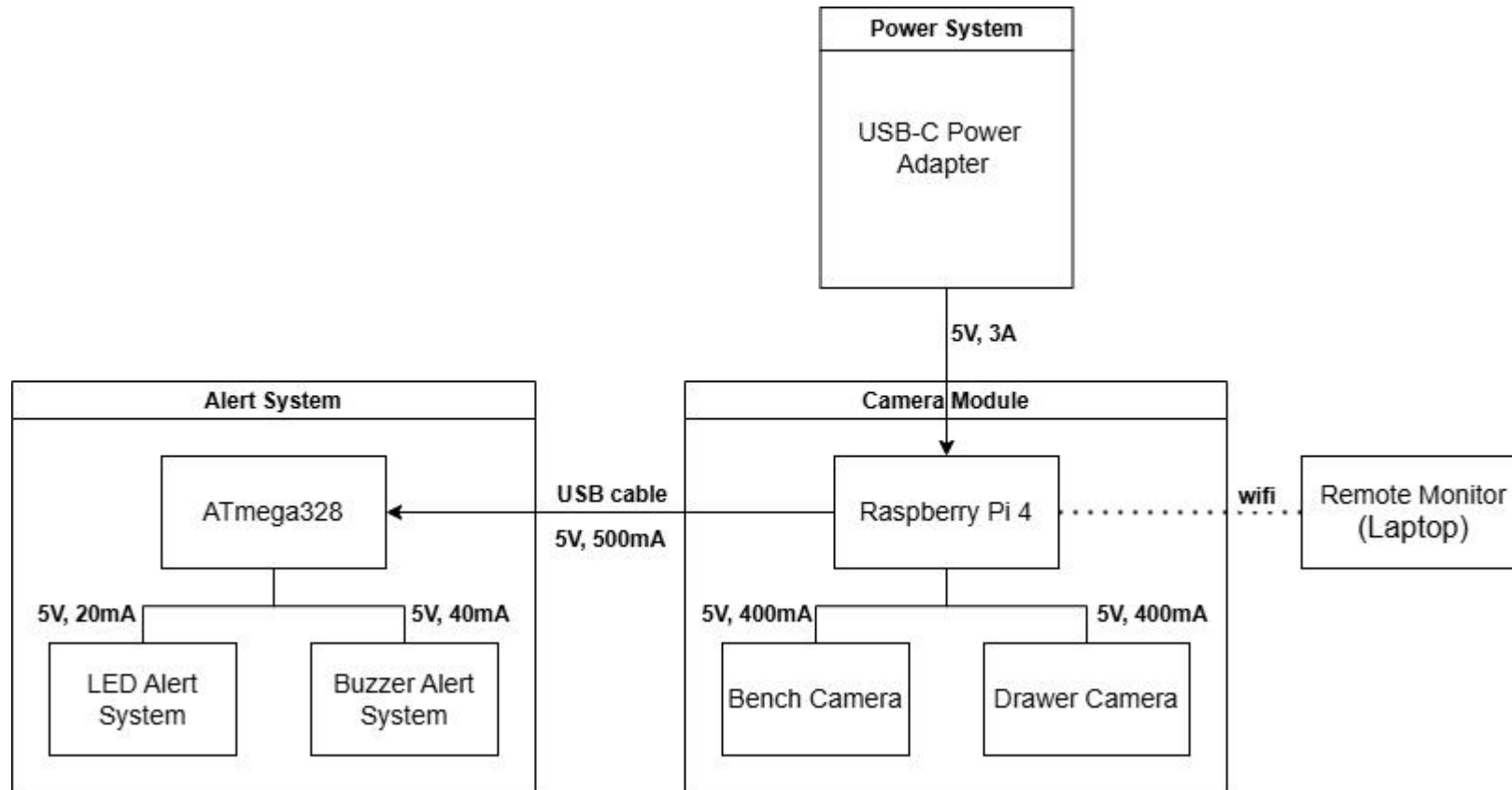Allows learning new tool categories (custom labeling)

Project Design

Image Detection (Raspberry Pi)

Description:

• Use YOLO-based model to detect tools on bench and in drawer.

• Use two webcams connected to Raspberry Pi.

• Run detection every 10 seconds and check tool status.

Requirements:

• Detect and classify all tools in the scene.

• Differentiate between present, added, and missing tools.

• Track missing tools for over 30 seconds.

Camera Module

Raspberry Pi 4

5V, 400mA   5V, 400mA

Bench Camera   Drawer Camera
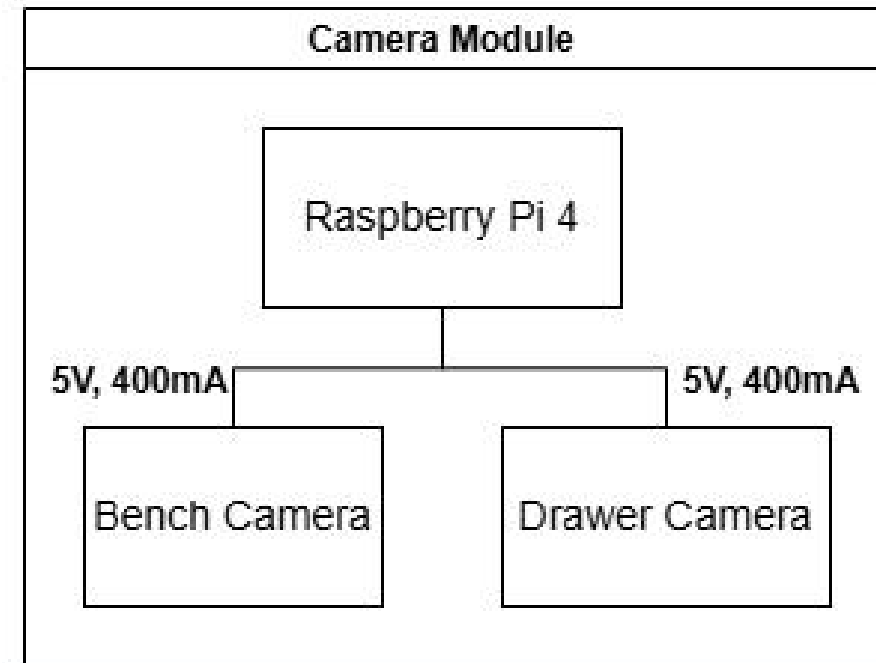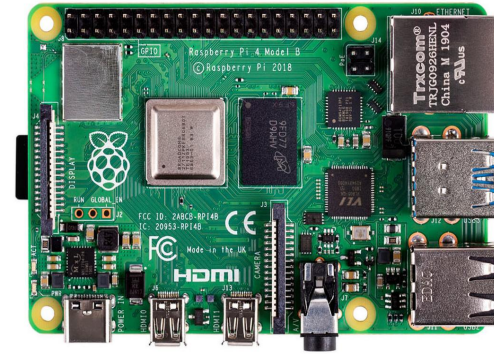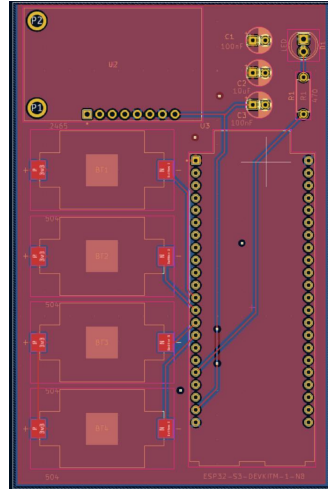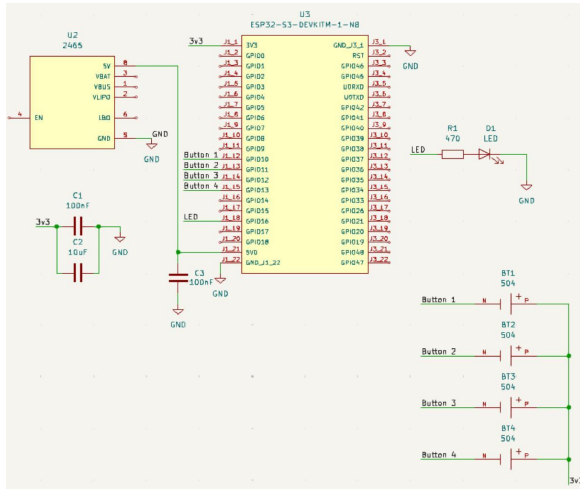
Alert Response

Description:

• ATmega328 receives signal and activates alert system.

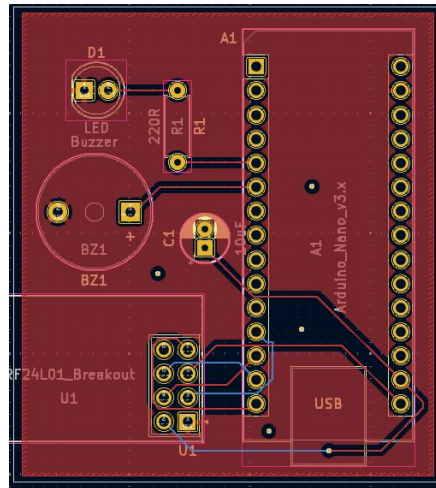• LED blinks for 10 sec and buzzer sounds for 2 seconds.

Requirements:

• React immediately to received "ALERT".

• Audible and visual signals must be clear and noticeable.

• Must be power-efficient and responsive.

Bench Organizer
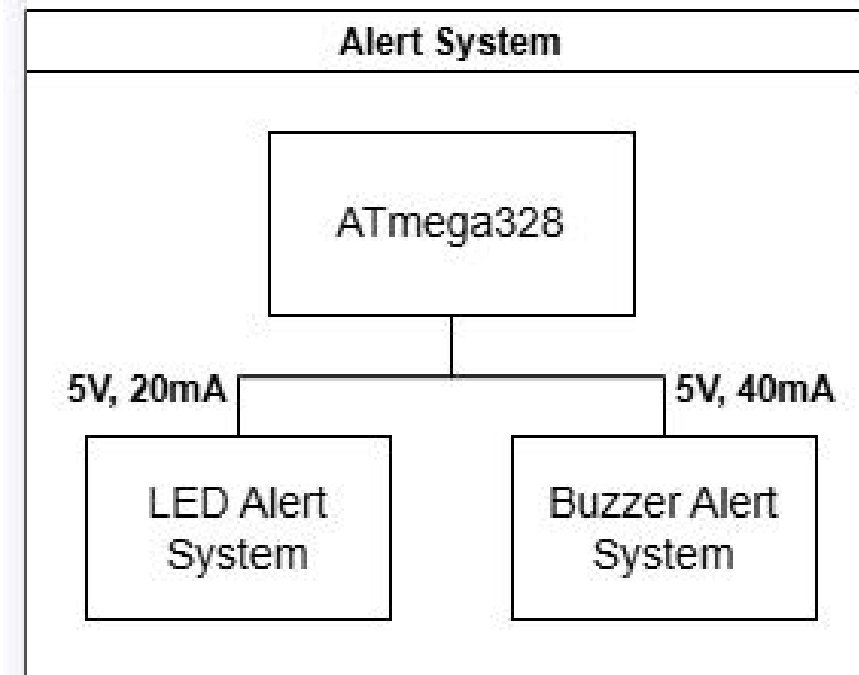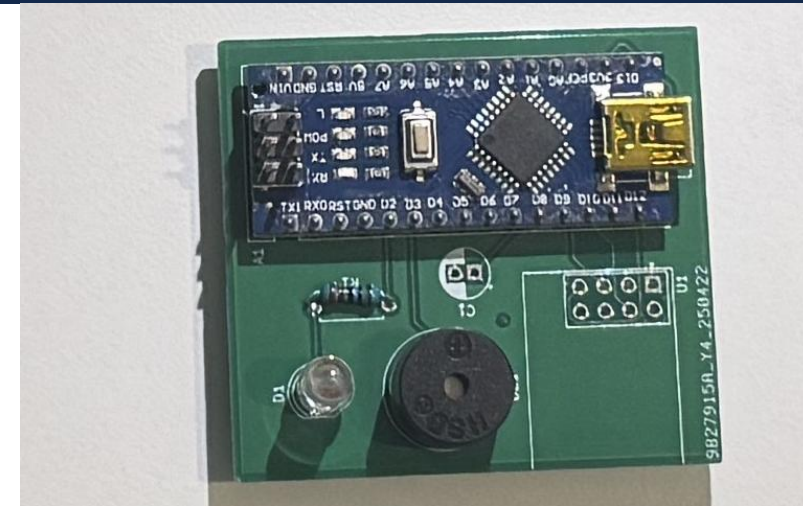
Original design(no longer used):

- ESP32
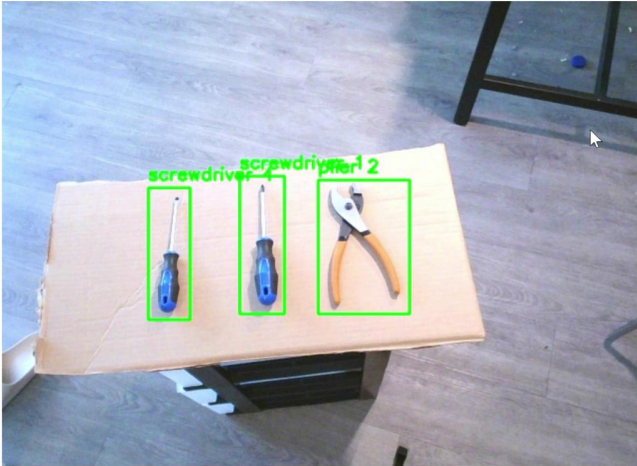
- Camera Module

- OLED screen
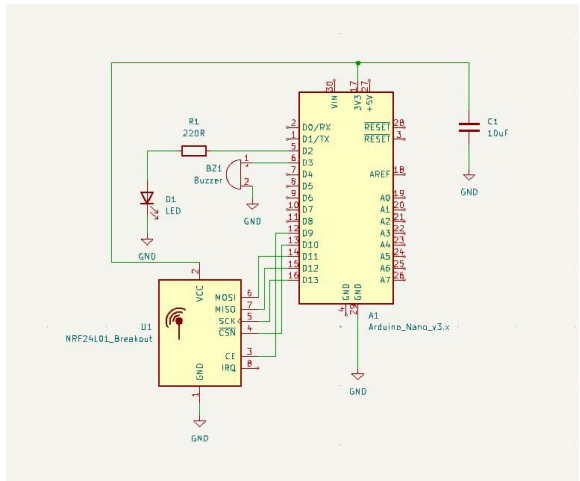
Final design:

- Raspberry Pi 4 with YOLOv5 object detection

- Two webcams: one for bench, one for drawer

- ATmega328 + LED + buzzer for alerts

- Fully remote control via laptop

Project Build & Test

- Python + YOLOv5 on Raspberry Pi detects tools every 10s

- Tool info (present/missing) shown on laptop UI

- If a tool is missing for over 30 seconds:
  → Raspberry Pi sends signal to ATmega328
  → ATmega328 receives and activates LED & buzzer

- Demo includes live webcam feed from Pi + alerts on missing tools

Tool Tracker

1	screwdriver	present	14:25:26	region_1
2	plier	present	14:25:26	region_1
3	plier	missing	14:24:33	region_2
4	screwdriver	present	14:25:26	region_0

Model Accuracy

Test Environment	Precision	Recall	Accuracy
Bench Tools (Camera 1)	92%	88%	90%
Drawer Tools (Camera 2)	89%	85%	87%
Combined	90.5%	86.5%	88.5%

Successes & Challenges

Success:

- Accuracy & Responsiveness:
  - Detection accuracy ~90% for trained tools
  - Each detection completes within ~1.5 sec

- Alert Mechanism:
  - LED + buzzer alert triggers correctly when tool is missing for > 30s

Successes & Challenges

Not Fully Met:

- Extended Functionality:
  - No real-time learning of unknown tools
  - User labeling not yet implemented
  - Current system only tracks pre-trained tool classes
  - System cannot functions well under different lighting

Conclusions

• We successfully implemented a YOLO-based system to detect missing tools in real time

• Communication with ATmega328 enables effective visual & sound alerts

• Dual-camera setup enhances monitoring coverage

What We Learned

• Hardware units are prone to failure(e.g. loose connections, poor soldering, unstable power)

• Order multiple units at once for backup and faster troubleshooting

• Early hardware and integration tests are crucial for system stability

Future Work

• Train larger custom YOLO model for more tool types

• Add support for multiple drawers/cameras

• Add persistent tool tracking with timestamps

• Deploy system in real lab setting

Thanks for Listening!

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The Grainger College of Engineering

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN