ECEGR 4640: Internet of Things (IoT)

Danny Woo: **GUARDEN - Garden Urban AI Rodent Detection and Environment Node**

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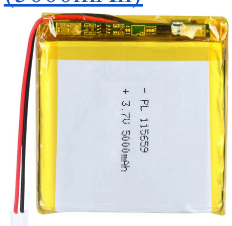
Background

Established in 1975, the Danny Woo Community Garden is a historic urban P -Patch located in Seattle's International District/Chinatown. Spanning approximately 1.5 acres on a steep hillside overlooking Elliott Bay and downtown Seattle, it serves as an essential resource for the local community, who rely on the garden's produce for food. The garden is currently facing an ongoing rat infestation, as rats consume fallen fruits and vegetables, significantly reducing harvest yields. Our team's proposed solution is to deploy multiple Grove Vision AI V2 Kits, integrated with AI/ML object detection, to automatically monitor and map rat activity across the garden. This will enable targeted identification of nesting areas and allow for efficient, data-driven pest control.

Methodology

System Architecture & Hardware

Item	Quantity	Unit Cost	Total	Notes
Grove Vision AI V2 Kit	4	–	–	Provided On campus
LiPo batteries (5000mAh)  	4	$15	$60	3.7V with protection
Miscellaneous (obtainable via Lab/MakerSpace)	-	-	-	Wire, connectors, testing supplies, mounting hardware, 3D printed enclosures, microSD cards
		Projected total:	~$200 (est. taxes)	

Data Collection Pipeline

The data collection pipeline consists of four main stages:

Edge Detection → Data Transmission → Cloud Ingestion → Storage & Visualization

The system is designed for low-bandwidth efficiency, privacy preservation, and reliable operation in outdoor conditions.

On-Device Detection (Grove Vision AI V2)

//// The ESP32-CAM wakes from sleep when motion is detected, captures an image, and runs a lightweight AI model (TensorFlow Lite) to identify rats. Hardware modifications, such as the removal of IR sensors from the lenses, will be made to the camera modules to enhance performance under low lighting conditions. If a rat is detected with sufficient confidence (>70%), the system logs the event with timestamp, camera location, and confidence score. All processing happens on-device to preserve privacy and minimize bandwidth. Events are temporarily stored on a microSD card as backup.

Data Transmission (Wi- Fi)

//// Detection events are transmitted to the cloud via WiFi using HTTP POST requests. Each event is a small JSON packet (~200 bytes) containing camera ID, timestamp, confidence score, and system health data (battery level, light level).

LoRaWAN Implementation:
WiFi will be established using a mesh connectivity system. ESP32-LoRa modules will serve as nodes within this mesh, enabling devices to interconnect by bouncing WiFi signals off one another. Additionally, a LoRaWAN gateway will be installed on-site, which will communicate with the LoRa hub situated at Seattle University.

WiFi Troubleshooting:
If WiFi fails, events queue locally and retry transmission up to 3 times. The system uses HTTPS for secure communication.

Cloud Ingestion (ThingSpeak)

/// ThingSpeak receives detection events through its REST API and stores them in channel fields. Each camera sends data to a shared channel with 8 fields: camera ID, confidence score, detection count, battery voltage, light level, and reserved fields for future expansion. ThingSpeak's free tier allows updates every 15 seconds, sufficient for our event-driven approach.

Storage & Visualization

/// ThingSpeak stores all historical data and provides a real-time web dashboard accessible from any browser. The dashboard displays detection timelines, activity heatmaps showing which cameras see the most rats, peak activity hours, and system health monitoring. Data can be exported as CSV for additional analysis in Python or MATLAB. Danny Woo staff may access the dashboard via a public URL with no required login.

Deliverables

Hardware Systems

//// 4-6 fully deployed, weatherproof ESP32-CAM nodes with solar power systems installed at strategic locations throughout Danny Woo Community Garden.

AI Detection Model

/// Trained and optimized TensorFlow Lite rat detection model with documented performance metrics (precision, recall, confidence thresholds). Our team will use an already developed dataset for training the model.

ThingSpeak Dashboard

Real-time web dashboard displaying rat activity patterns, detection timelines, location heatmaps, peak activity hours, and system health monitoring.

Data Analysis Report

Comprehensive report identifying high-activity zones, peak detection times, and actionable recommendations for targeted pest control and potential nesting area locations.

Technical Documentation

- System architecture diagram
- Camera deployment map with GPS coordinates
- Firmware source code (GitHub repository)
- Hardware assembly guide

User Documentation

- Dashboard access guide for garden staff
- System maintenance procedures (camera cleaning, battery checks)
- Basic troubleshooting guide

Timeline

Anticipated Start Date	**Anticipated Due Date**	**Topic**	**Members**
ASAP	10/28/2025	Order Components	All
10/28/2025	11/11/2025	Hardware Systems	All
10/28/2025	11/11/2025	AI Detection Model	EM
10/28/2025	11/11/2025	ThingSpeak Dashboard	RC
10/28/2025	11/11/2025	Finished Prototype	All
11/11/2025	11/25/2025	On-site Preparation	TT, BV, NRC
11/25/2025	12/01/2025	Field Testing	All
12/05/2025	12/05/2025	Field Deployment	All

12/05/2025	12/09/2025	Technical Documentation	EM
12/05/2025	12/09/2025	User Documentation	RC, TT, BV, NRC
12/05/2025	12/09/2025	Final Presentation	All

Final Presentation (December 10, 2025)

Results presentation to Danny Woo Community Garden management and ECEGR 4640 class, including live dashboard demonstration and key findings.

References

[1] Jaulin, Edouard. "Rapport 2024." ENSTA Bretagne (2024).

[2] Leu Mei Xin, & Nik Fadzly N Rosely. Development of Machine Learning Wildlife Camera Using ESP32 CAM for Small Mammals. Pertanika Journal of Science & Technology (2025).

[3] Rithik Krisna. ESP32 cam based Object Detection & Identification using Edge Impulse. Circuit Digest (2024).

[4] Jaulin, Edouard. "Rapport 2024." ENSTA Bretagne (2024).

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* see full project code files @ https://github.com/ezekielmitchell/GUARDEN