

Edge AI for Automated Olive Fruit Fly Counting Using Smart McPhail Trap

Objective: How can small-object detection be deployed energy-efficiently
on edge IoT devices?

Monitoring Olive Fruit Fly Populations

- Olive fruit fly (*Bactrocera oleae*) is a major agricultural pest
- McPhail traps widely used for monitoring
- Current process:
 - Manual inspection
 - Time consuming
 - Requires field visits

Goal:

Automate fly counting using **low-cost smart traps with edge AI**

System Pipeline

Trap device:

1. Capture image of trap contents
2. Collect environmental data
3. Run **on-device inference**
4. Transmit:
 - fly count
 - environmental measurements

Advantages:

- Reduced network bandwidth
- Lower cloud processing cost
- Real-time population monitoring



Key Question

What configuration provides the **best trade-off between accuracy and energy efficiency?**

We evaluate:

- Detection accuracy ([mAP@0.5](#))
- Inference time
- Power consumption
- Energy per inference
- Hardware utilization

Target outcome:

Optimal deployment configuration for edge devices

Dataset and Detection Model

Dataset

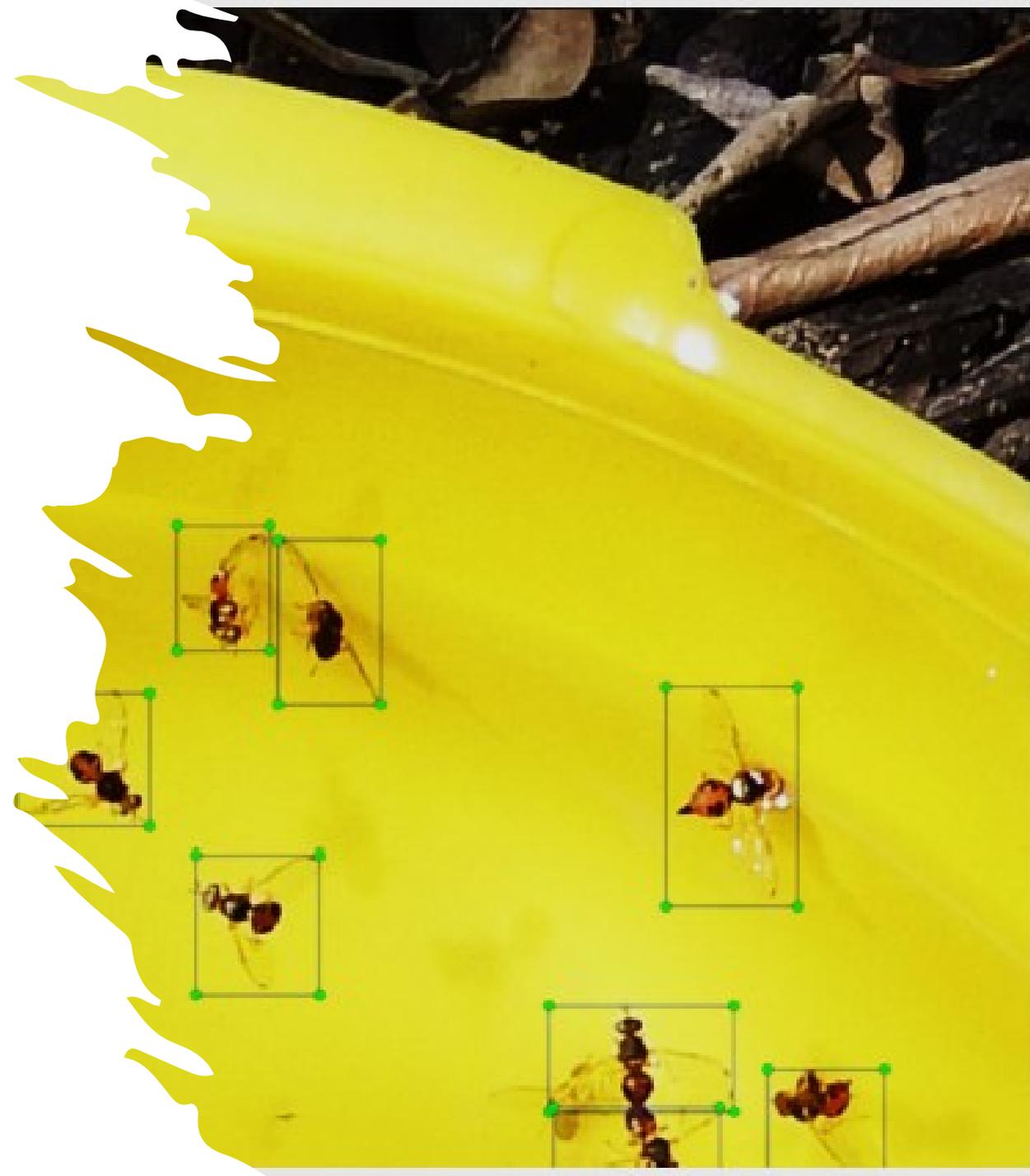
- 777 images from McPhail traps
- Real trap conditions
- Variable insect density

Detection Model

- YOLOv8-XL
- trained to detect:
 - Olive fruit fly

Output

Bounding boxes and fly count per image



Edge Hardware Platform

Deployment Device

Raspberry Pi

Measurements recorded

- Inference time
- Power consumption
- CPU usage
- GPU usage
- Temperature

Energy metric

Energy per inference

$$\text{Energy} = \text{Power} \times \text{Inference Time}$$



Inference Strategies

Two inference approaches are evaluated.

Strategy 1 — Full Image Inference

- Run detection on the **entire image**

Strategy 2 — Quadrant Inference

- Split image into **4 equal quadrants**
- Run inference on each quadrant
- Combine detections

Purpose:

Improve detection of **small insects**

Image Resizing Experiment

To simulate edge constraints we vary **internal inference resolution**.

Procedure:

- Start from **largest resolution supported**
- Gradually decrease resolution
- Step size: **320 pixels**
- Stop when insects become too small for reliable detection

For every resolution we record:

- accuracy
- resource usage
- energy consumption

Experimental Procedure

For each configuration:

1. Load the **777 image dataset**
2. Run inference using:
 - full image strategy
 - quadrant strategy
3. Repeat across all resizing values

Between runs:

- Raspberry Pi **enters sleep mode**
- prevents thermal bias

Collected metrics:

- [mAP@0.5](#)
- inference time
- energy per inference
- system utilization

Expected Outcome

Goal:

Identify **optimal deployment configuration** for edge traps.

Decision based on:

- acceptable detection accuracy
- minimal energy consumption
- stable hardware operation

Potential impact:

- scalable pest monitoring
- reduced field labor
- real-time agricultural intelligence

Future Research Directions (1): System Expansion & Field Operations

Autonomous Data Collection

- Data harvesting from smart olive fruit fly traps using **drones**

Field Maintenance Support

- Data harvesting via **automatic off-loading to a mobile application** during manual trap cleaning / reset

Precision Agriculture Integration

- **Direct communication between smart traps and drones** for targeted pesticide spraying

Trap Hardware Extensions

- Integration of **bait-spraying capability** within the trap system

Trap Automation

Trap Automation

- Reduction of manual maintenance requirements through:
 - automatic removal of old bait
 - internal cleaning of the trap canopy
 - automatic bait replenishment
 - insect lifting mechanism using a mesh system to improve visual imaging

Future Research Directions (2): Sensing, Networking & System Generalization

Advanced Vision Capabilities

Extension of the visual recognition system with:

- **Multispectral imaging**
- **Genus-level insect classification**
- Detection of **oviposition readiness**

Multi-Modal Detection

- Integration of **acoustic insect recognition**

Network Architecture

- **Ad-hoc connectivity** between traps
- Additional **gateway nodes for Internet connectivity**

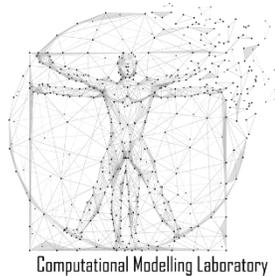
System Transferability

- Transfer of system knowledge and methodology from **crop-pest systems (olive-fruit fly) to other crop-pest monitoring scenarios**

Thank you for your attention

Questions?

karydis@ionio.gr



I M N H

**INSTITUTE OF MECHANICS
OF NATURAL HAZARDS**

IONIAN UNIVERSITY · GREECE