Tetsuzakura Knights

ROBOTICS DOJO 2026 · WASTE-MANAGEMENT CHALLENGEt

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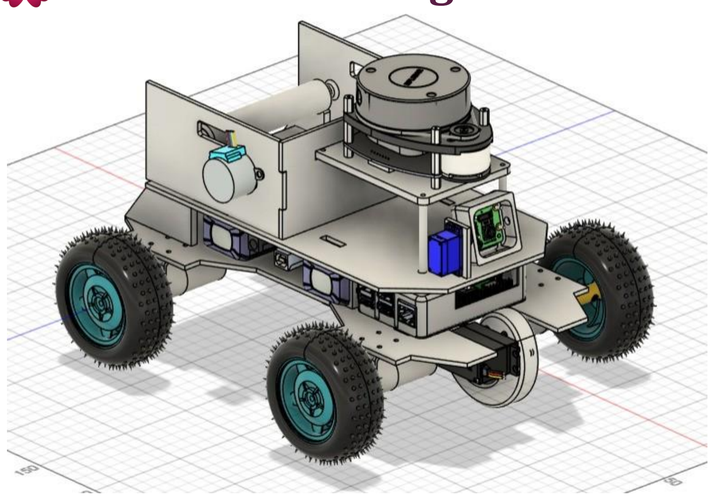
Abstract

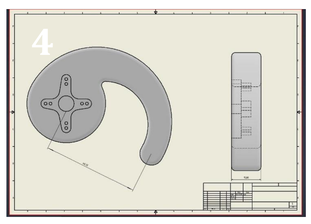
Rapid urbanization has made municipal and industrial waste handling a pressing engineering challenge, and manual sorting is slow and costly. Therefore, a compact autonomous mobile robot is developed for the Robotics Dojo 2026 waste-management challenge. The robot operates in two phases. In a manually driven mapping phase, a [2D LIDAR]-based SLAM pipeline builds a map of the game field. In the subsequent fully autonomous phase, the robot localizes against the map, and navigates to a display screen where it should classify waste shown as plastic, metal, or organic. The robot then drives to the matching loading station to secure the waste and cross the gravel, sand and ramp terrain while avoiding the placed obstacles. Finally, the robot should identify the colour-coded offloading station, deposit the item and proceed to the finish position.

Introduction

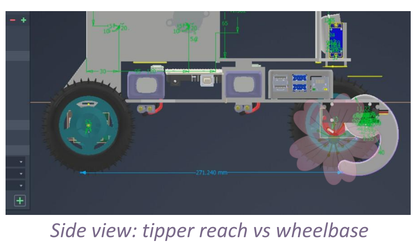
The competition concentrates the demands for a safer, faster and consistent robot within a 3-minute autonomous phase, preceded by a 3-minute manual mapping phase. Because the tasks run in sequence, an error in any stage, propagates downstream.

Mechanical Design





Servo tipper arm



Side view: tipper reach vs wheelbase

Electrical & Power

ESP32-S3

real-time tier

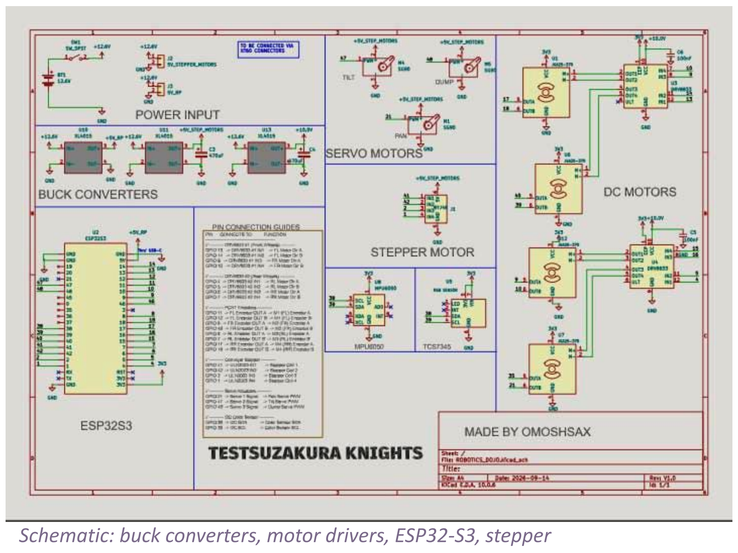
- Wheel PI loops · encoders · 20 Hz
- IMU · colour · servos · stepper
- EKF odometry · 0.5 s failsafe

micro-ROS · UART · 460,800 baud

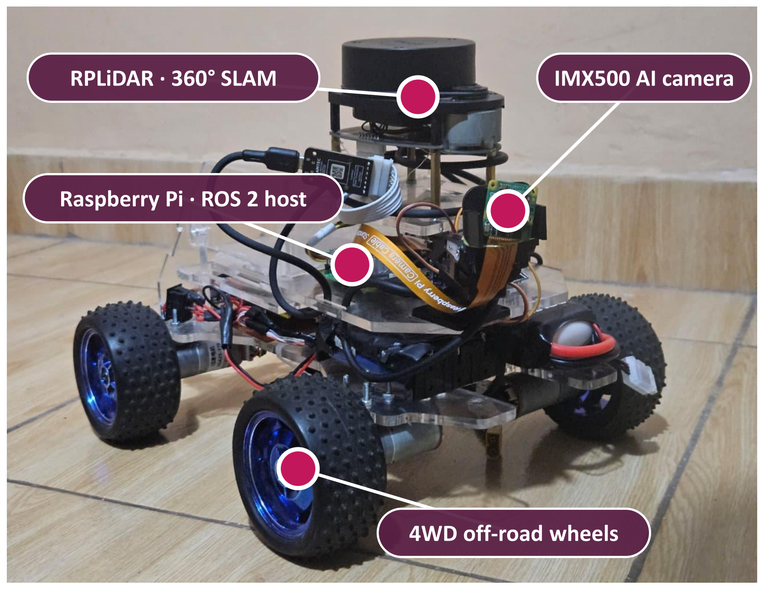
Raspberry Pi

ROS 2 Jazzy host

- twist_mux · rosbridge · agent
- RPLiDAR SLAM · Nav2 (AMCL + MPPI)
- IMX500 vision · mission logic

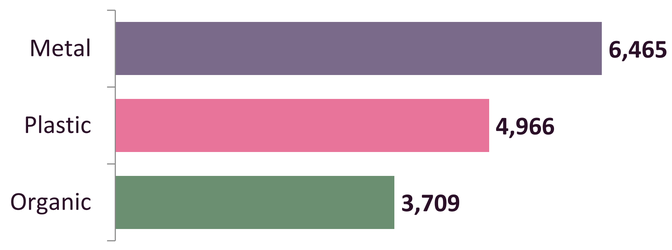


Schematic: buck converters, motor drivers, ESP32-S3, stepper



Edge-AI Pipeline

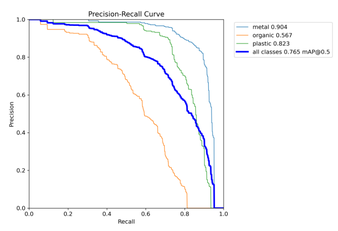
1 Annotate	2 Train	3 Quantise	4 Deploy
3,868 images 3 classes	YOLO11n 45 epochs	INT8 PTQ Sony MCT	IMX500 .rpk on-sensor



Why nano? Only YOLO11n is supported by the Ultralytics IMX500 (.rpk) export, so the YOLO11s baseline was retrained as YOLO11n.

Detection Performance

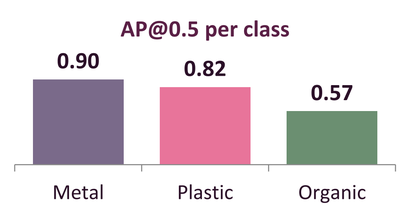
0.765	0.74	100%
mAP@0.5, all classes	best F1 at confidence 0.487	precision at confidence 0.962

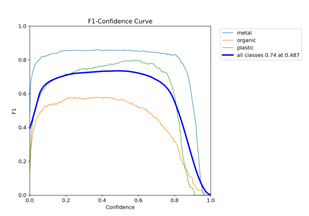


PR curves: metal 0.904 · plastic 0.823 · organic 0.57 AP

pred ↓ / true →	metal	organic	plastic	bkgd
metal	**0.92**	0.04	0.05	0.10
organic	0.02	**0.79**	0.16	**0.56**
plastic	0.02	0.03	**0.73**	0.34
bkgd	0.04	0.14	0.06	–

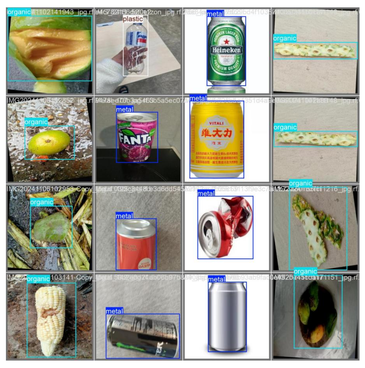
Normalised confusion (columns = true). 56% of background is read as organic.



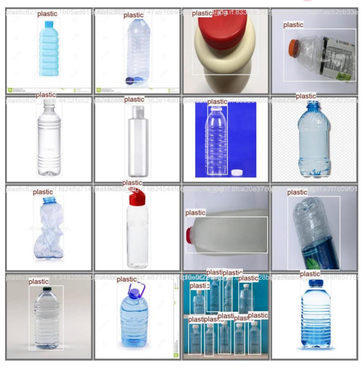


F1 vs confidence

Field-Ready Predictions



Organic & metal: tight boxes on cans and produce



Plastic: bottles detected across scales

Innovations

1. Configuring the Raspberry AI Camera with Ubuntu 24.04. The Sony IMX500 is a pioneering intelligent vision sensor that embeds AI processing directly into the image sensor pipeline.
2. Lidar/Laser Odometry. Lidar/Laser odometry in ROS2 estimates a robot's ego-motion and pos e changes by matching consecutive LiDAR scans (using 2D laser scans or 3D point clouds) and publishing odometry and tf transforms
3. Custom CAD to URDF Fusion Script. The fusion exporter script is written in python and interacts directly with the Fusion API.

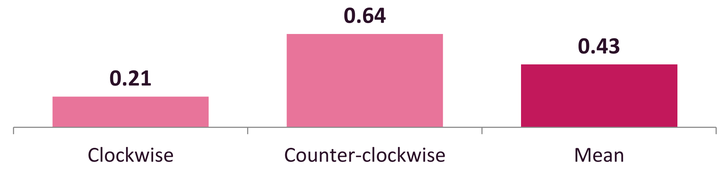
Motor Control & IMU

Identify K, τ, θ → **Tune PI · SIMC** → **Verify 30 rpm**

$$G(s) = K \cdot e^{-\theta s} / (\tau s + 1)$$

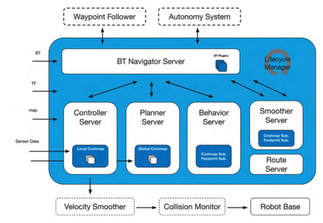
$$K_p = \tau / [K(\tau_c + \theta)] \quad \cdot \quad \tau_I = min\{\tau, 4(\tau_c + \theta)\}$$

accept: overshoot ≤ 5 % and ripple ≤ 3 rpm

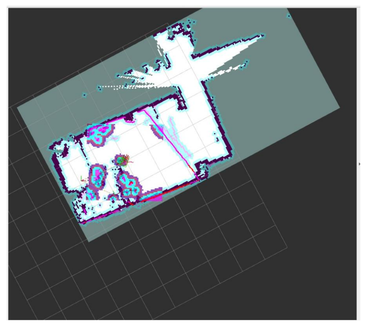


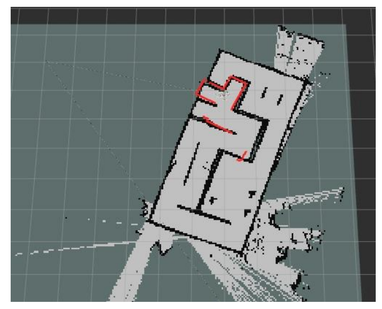
≈ 1.5° per full turn, absorbed by LiDAR scan matching

SLAM & Nav2 Navigation



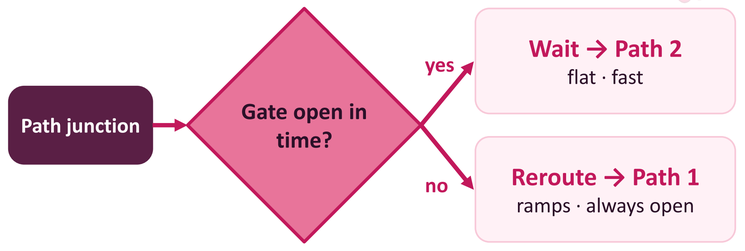
Localise	AMCL · 2,000 particles
Global	NavFn · A* on 2D grid
Local	MPPI · 15-step horizon
Costmap	Voxel · 16 layers to 2 m
Safety	Collision monitor





slam_toolbox map, inflated costmap and AMCL pose, visualised in RViz

Time-Aware Routing



Score: efficient decision 10 · inefficient 5 · fail 0

Impact & Next Steps

- Reliable end-to-end pipeline on a 30 cm, ≤ 24 V platform
- Scalable blueprint for low-cost robotic waste management
- Next: ≥ 300-image INT8 calibration, more organic data, firmware gyro-scale fix, floor-tuned PID

Sakura Spirit

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RDJ2026 dataset

Robotics Dojo