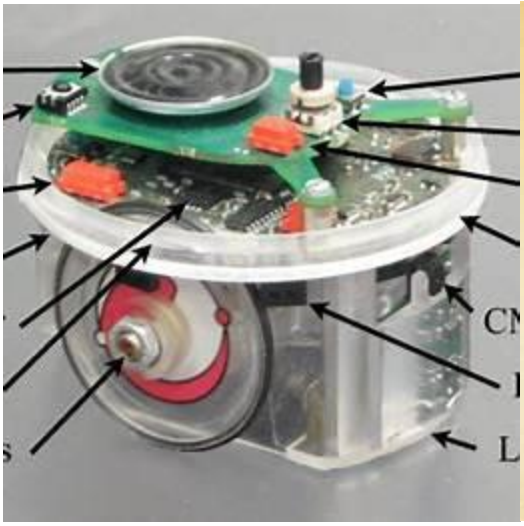

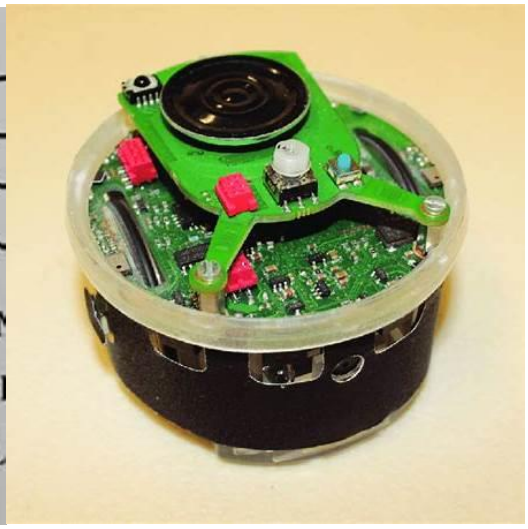

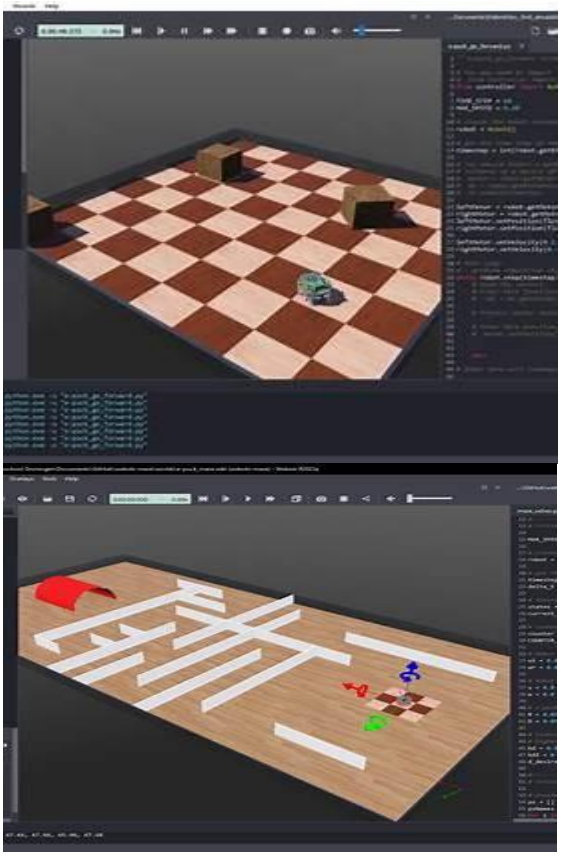

SEO package (Project 1)

Primary SEO title (recommended):
Smart e-Puck Car: Vision-Based Pedestrian & Obstacle Detection for Safer Line-Following Robots

Alternate titles:

- Building a Safer Line-Following Robot with Real-Time Vision and Sensor Fusion
- From Line Following to Collision Avoidance: A Smart e-Puck Autonomous Prototype in Webots
- Vision + Control Loops: A Practical Robotics Safety System in Simulation

URL slug: `smart-epuck-vision-pedestrian-obstacle-detection-line-following`

Meta description (155–160 chars):
MuFaw AI Research Lab built a smart e-Puck robot that follows lanes and detects pedestrians/obstacles in real time, with auditable safety logic.

Target keywords:

- Primary: *vision-based obstacle detection robot, pedestrian detection robotics, line following robot with OpenCV*
- Secondary: *Webots supervisor logging, sensor fusion mobile robot, embedded real-time perception, collision avoidance prototype*

Smart e-Puck Car: Vision-Based Pedestrian and Obstacle Detection in a Line-Following Environment

MuFaw AI Research Lab | Autonomous Robotics & Real-Time AI Decision Systems

Autonomous robots don't fail because they can't move. They fail because they can't **perceive + decide + act** fast enough when the environment changes.

In this project, MuFaw AI Research Lab built a complete autonomous prototype on an e-Puck platform that can:

- **Follow a road line continuously**
- **Detect pedestrians and obstacles using vision (OpenCV)**
- **Estimate distance and decide safely**
- **Stop/slow for "pedestrians" and execute avoidance for "obstacles"**
- **Log every decision and metric via a supervisory controller for verification**

The result is a compact, auditable demonstration of how real-world autonomous systems are engineered: not as a single "AI model," but as a **sensing + control + safety logic + validation** pipeline.

Why this project matters (non-technical summary)

Pedestrian detection and collision avoidance are central problems in autonomy—so central that regulators are moving toward requiring automatic emergency braking systems that detect pedestrians (in the automotive domain). Academic reviews also frame pedestrian collision avoidance as a key requirement for safe autonomous vehicles.

Even outside cars, the same safety principle applies to **autonomous mobile robots (AMRs)** used in warehouses, hospitals, and industrial sites: robots need **redundant sensing** and reliable decision-making to avoid collisions.

This project is a controlled, simulation-validated prototype that demonstrates these safety fundamentals end-to-end.

What we built (technical + business)

Smart e-Puck Car is a Webots-based autonomous robot system that combines:

- **Line following** (continuous path tracking)
- **Vision perception** (OpenCV processing for object detection/classification)
- **Distance estimation** (sensor fusion using camera + odometry + simulator ground-truth)
- **Deterministic safety logic** (auditable thresholds and responses)
- **Supervisor-driven validation** (measurement, scenario control, reproducibility, logging)

Webots provides a full robotics simulation environment designed for modeling, programming, and simulating robots. We used Webots **R2025a** in this implementation.

System overview

Real-time pipeline (high level)

1. **Capture sensor inputs** (camera frames + proximity sensors + odometry)
2. **Detect the line** and compute lateral error
3. **Run vision detection** to classify objects as pedestrian vs obstacle
4. **Estimate distance** and track proximity trends
5. **Apply safety policy** (slow/stop or evade)
6. **Generate motor commands** (speed/turn)
7. **Log everything** via supervisor: detections, decisions, latencies, minimum distance, collisions

This is the practical structure used in real autonomous systems: perception feeds a policy, policy feeds control, and the whole loop is measurable.

Core capabilities

1) Robust line following (continuous control)

The robot stays centered on a predefined road line using real-time feedback correction (think "autopilot for a lane," but in a controlled environment).

Where it's used in the real world:
Line-following concepts appear in many "guided" vehicle setups (e.g., fixed-route indoor transport). Research and industry often describe guided vehicles as material-handling systems in manufacturing and logistics.

2) Vision-based detection with OpenCV

OpenCV is widely used for real-time computer vision and is explicitly optimized for real-time applications with Python support.
We used OpenCV-based preprocessing and detection logic to identify and classify objects in the robot's forward view.

3) Safety decisions that are deterministic and auditable

Instead of "black-box" behavior, the system uses:

- explicit thresholds,
- explicit state transitions (e.g., cruise → slow → stop),
- explicit avoidance triggers for obstacles.

This matters for validation: when you replay logs, you can explain **why** the robot acted.

4) Sensor fusion for more reliable distance reasoning

In autonomy, combining sensors is a standard way to improve reliability through redundancy. Here, we fuse:

- camera-based spatial cues,
- odometry trends,
- and simulator ground-truth (for validation) via the supervisor.

5) Supervisor-based verification and reproducible testing

Webots supports a **Supervisor** concept: a special controller with extra powers to monitor and manipulate the simulation (commonly used for measuring trajectories and collecting data).
We used it to:

- generate controlled scenarios,
- record metrics,
- and keep tests reproducible.

Platform: why e-Puck + Webots?

The e-Puck robot is a well-known education/research platform originally designed for engineering education.
Its specs include multiple sensors relevant to autonomy prototyping, including **infrared sensors** and a **camera** (depending on variant/config).
Webots tutorials also commonly use e-Puck as a reference robot in simulations.

This combination is ideal for building systems that are:

- fast to iterate,
- easy to validate,
- and structured like real autonomy stacks.

Real-world use cases this project maps to

This prototype is simulation-based, but the architecture maps cleanly to real products and deployments:

1. **Warehouse/Factory material movement (guided autonomy)**
   Automated guided vehicle (AGV) deployments are widely discussed in industry and research for material handling in companies.
   A “line-following” style constraint can represent fixed routes in structured facilities.
2. **Indoor delivery robots (hospitals/campuses)**
   Structured navigation + human-aware stopping behavior is a baseline safety requirement when robots share space with people.
3. **Safety testing of perception + response logic**
   Because the supervisor can create deterministic scenarios and log metrics, this setup works well for:

- regression tests (“did safety behavior change?”),
- latency checks,
- minimum-distance constraints.

4. **Embedded autonomy prototyping**
   OpenCV is frequently used in embedded/real-time vision pipelines, but embedded deployments face tight latency and resource constraints—exactly the kind of constraint this project is designed to respect architecturally.

What makes this a "portfolio-grade" autonomy project

Most robotics demos show only one piece (line following *or* detection). This project is end-to-end:

- **Perception:** vision + classification
- **Decision:** human-aware vs obstacle-aware policy
- **Control:** motor commands + correction loops
- **Validation:** supervisor, logs, repeatable tests
- **Transparency:** deterministic logic, auditable thresholds

That is the structure clients care about because it's the difference between "a demo" and "an engineering system."

Validation metrics we log (examples)

We designed the system so it can be measured objectively, including:

- detection confidence per frame,
- decision-to-actuation latency,
- minimum pedestrian distance,
- avoidance success rate,
- collision events,
- line-following lateral deviation over time.

(We do not claim real-world vehicle readiness; this is a simulation-validated prototype.)

Tech stack

- **Simulation:** Webots R2025a
- **Robot model:** e-Puck (sim + platform-aligned design)
- **Language:** Python
- **Vision:** OpenCV
- **Validation:** Webots Supervisor APIs for monitoring + logging

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FAQ (SEO-friendly)

Is this production-ready autonomous vehicle software?
No. This is a simulation-validated autonomy prototype designed to demonstrate safe decision-making loops and verifiable behavior in controlled scenarios.

Why not use a deep learning model for detection?
Deep learning can be added, but this project emphasizes explainable, deterministic behavior and real-time feasibility. The pipeline is structured to swap in learned detectors later.

What is "sensor fusion" and why does it matter?
It's combining multiple sensor signals so the system remains reliable even when one signal is noisy or partially blocked; redundancy is a standard safety pattern in mobile robotics.

Why use Webots + a Supervisor?
Webots provides a full simulation environment and the Supervisor API enables measurement, scenario control, and reproducible validation—critical for safety testing.

CTA (MuFaw AI Research Lab)

- **Request the full technical report & architecture notes:** Contact MuFaw
- **Schedule a technical deep-dive:** Book a discussion with our team
- **Explore related robotics projects:** Browse MuFaw Robotics + AI portfolio

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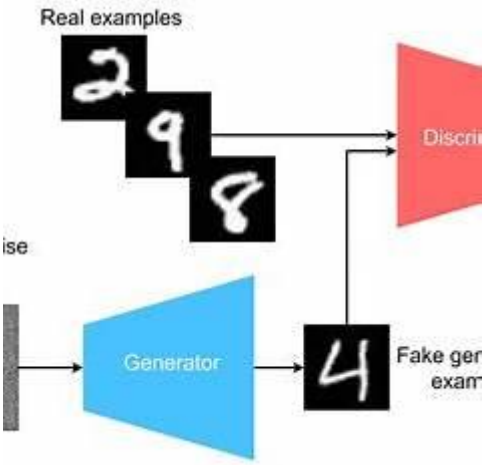
Real examples
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