AI & SUSTAINABILITY IN VET EDUCATION

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Title of WP: WP3 – AI-SAVES@ProjectHub

Activity Reference: AI Waste Classifier – LED-Based Material Recognition

Logo:

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1. **Project Title:**

   AI Waste Classifier – LED-Based Material Recognition for Sustainable Education

2. **Project Category:**

   Artificial Intelligence • Computer Vision • Sustainability

3. **Project Description:**

   This project introduces a simplified AI system that detects and classifies different recyclable materials using a Raspberry Pi camera and a lightweight TensorFlow Lite model.

   The system identifies common materials—paper, plastic, and metal—and activates a corresponding LED to visually indicate the detected category while continuously displaying the live camera feed and the recognized material on screen.

   - Green LED → Paper
   - Yellow LED → Plastic
   - Red LED → Metal

   Students train their own AI model using Teachable Machine by capturing real-world images of waste materials and exporting it in TensorFlow Lite format for edge inference.

   The project emphasizes sustainability awareness, AI implementation, and hands-on experimentation without requiring any robotic movement or complex wiring.

4. **Keywords:**

   AI, Raspberry Pi, Computer Vision, TensorFlow Lite, Teachable Machine, LEDs, Recycling, Sustainability

5. **Target Audience:**

   Vocational students (2nd-year) and educators interested in AI, environmental sustainability, and IoT fundamentals.

   Ideal for students with limited robotics experience who wish to understand how AI can promote ecological responsibility.

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6. **Project Objectives:**

- Learn to train a simple image classification model with Teachable Machine.
- Understand how to deploy and run AI models on Raspberry Pi.
- Map visual recognition results to physical outputs (LED indicators).
- Foster awareness about recycling and environmental sustainability.
- Encourage critical thinking and experimentation with accessible technology.

7. **Project Timeline:**

Task	Estimated Hours	Description
Introduction & project overview	1 hour	Define goals and explain the link between AI and recycling
Dataset collection	2 hours	Capture 40–50 photos per class (paper, plastic, metal)
Model training in Teachable Machine	2 hours	Train, test, and export TensorFlow Lite model
Raspberry Pi hardware setup	3 hours	Configure Python environment and GPIO
LED wiring and testing	2 hours	Connect LEDs and verify manual control via script

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Task	Estimated Hours	Description
AI model integration	4 hours	Load model, run inference, and activate LEDs accordingly
Testing & calibration	3 hours	Adjust thresholds and verify detection accuracy
Final documentation & presentation	3 hours	Report findings and prepare sustainability reflection
Total	**20 hours**	

8. **Resources Provided:**

- Example Python scripts (classify_led.py, camera_test.py)
- Preformatted requirements.txt for dependency installation
- README.md with wiring guide and step-by-step execution
- Report template and grading rubric
- Example labels.txt structure for TensorFlow Lite model

9. **Tools and Technologies Used:**

- Hardware: Raspberry Pi 4/5, Raspberry Pi Camera V2/V3 (or USB camera), 3 LEDs with resistors (220–330 Ω), breadboard, jumper wires.
- Software: Python 3, OpenCV real-time visualization window (cv2.imshow) for continuous video display and text overlay with classification results, TensorFlow Lite Runtime, RPi. GPIO, Teachable Machine.
- Tools: Thonny IDE / VS Code, GitHub (optional), basic electronic toolkit.

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10. Step-by-Step Implementation Plan:

Phase A – Data collection & model training

a) Gather real images of paper, plastic, and metal waste.
b) Upload to **Teachable Machine** (Image Project).
c) Train and test until classification accuracy ≥ 80%.
d) Export TensorFlow Lite model and save as model/waste_model.tflite.
e) Create a corresponding labels.txt file (one class per line).

1. Phase B – Hardware setup

a) Connect the 3 LEDs to Raspberry Pi GPIO pins (16, 19, 26) with resistors.
b) Verify connections with a simple Python script to turn each LED on/off.
c) Connect the camera and test video feed using camera_test.py.

2. Phase C – AI integration

a) Install required libraries from requirements.txt.
b) Load and run inference using classify_led.py.
c) Continuously display the live camera feed using OpenCV (cv2.imshow).
d) Overlay on-screen text showing the detected material in real time.
e) Assign each predicted material to a specific LED colour (Red = Metal, Green = Paper, Yellow = Plastic).
f) Add a brief delay or smoothing logic to ensure stable LED transitions.

3. Phase D – Testing & validation

a) Test the model with new objects and mixed lighting conditions.
b) Measure recognition speed and accuracy.
c) Record a demo video showcasing the system's behaviour.
d) Discuss environmental implications and areas for improvement.

11. Evaluation Criteria:

- **Model Training (25%):** Quality and diversity of captured dataset.
- **Hardware Setup (20%):** Correct wiring and safe circuit design.
- **AI Integration (30%):** Functional inference and LED response accuracy. Includes functional real-time visualization with clear on-screen classification labels.

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- **Creativity & Presentation (15%):** Clear explanation and sustainable focus.
- **Team Collaboration (10%):** Shared roles, documentation, and reflection.

12. Languages Available:

English

13. Contributors:

- **Miren Arrien (Project Lead)** – Lead educator responsible for project development and coordination.
- **Enaitz Elejalde (Technical Expert)** – Hardware testing and wiring verification.
- **Aitor Rey (Technical Expert)** – Python programming and debugging.
- **Jokin Goioaga (Technical Expert)** – Computer vision and AI deployment.

14. Feedback and Continuous Improvement:

- Short progress reviews will be conducted after each phase (training, wiring, and testing).
- Final feedback will include a discussion on environmental impact and model performance.
- Students will propose improvements such as additional material categories, integration with an LCD screen, or sound feedback for accessibility.
- Documentation of lessons learned will contribute to future AI & Sustainability modules, fostering iterative improvement and responsible innovation.
- Future improvements could include integrating additional material categories or enhancing the graphical interface (e.g., showing detection confidence or bounding boxes).

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