PROJECT REPORT: Harvest AI

Turning Electronic Waste into Educational Opportunities

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Project Link: https://github.com/rohithaks-aks/HarvestAI-sustanibility

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1. Problem Statement

University engineering laboratories generate a significant amount of electronic waste (e-waste) each academic semester. Many discarded devices and circuit boards still contain **functional components** such as microcontrollers, sensors, integrated circuits, and power modules. However, these components are routinely thrown away due to three key challenges:

1. **Identification Gap:** Students are unable to visually recognize loose or unlabeled components found in discarded electronics.
2. **Safety Concerns:** Fear of electrical hazards (e.g., charged capacitors, batteries, or high-voltage components) discourages reuse.
3. **Convenience Culture:** Purchasing new, low-cost electronic components is often perceived as easier than salvaging existing ones, increasing overall waste.

The Core Challenge:
How might we use AI to democratize electronic component knowledge and make safe reuse more accessible than buying new hardware?

2. SDG Alignment

This project aligns with the following **United Nations Sustainable Development Goals (SDGs):**

Primary: SDG 12 – Responsible Consumption and Production

- **Target 12.5:** Substantially reduce waste generation through prevention, reduction, recycling, and reuse.
- **Alignment:** HarvestAI intervenes at the *reuse* stage by identifying and repurposing functional electronic components before they enter the waste stream.

Secondary: SDG 4 – Quality Education

- **Target 4.4:** Increase the number of youth and adults with relevant technical skills.
- **Alignment:** The system enhances hardware literacy by teaching students component identification, datasheet interpretation, and safe handling practices.

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3. AI Solution Overview

HarvestAI is a browser-based, **human-in-the-loop AI-assisted decision support system** designed to promote responsible electronic reuse in educational environments.

The system integrates three complementary AI-driven layers:

1. **Perception Layer (Computer Vision):**
   A lightweight MobileNet-based image classification model (implemented via TensorFlow.js) runs entirely in the user's browser to identify common electronic components.
2. **Knowledge Retrieval Layer (RAG-Inspired):**
   Instead of relying on a static database, HarvestAI retrieves up-to-date contextual information using the Wikipedia REST API. This ensures adaptability to new or manually entered components.
3. **Reasoning & Safety Layer:**
   A deterministic, rule-based safety engine scans retrieved information for hazard indicators (e.g., "lithium," "high voltage") and issues visual and voice-based warnings.

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4. Critical Thinking & Architectural Decisions

Several intentional design decisions were made to ensure **privacy, reliability, and safety**.

A. Privacy-First Edge AI

Decision:
Computer vision inference is executed entirely on the client-side using TensorFlow.js rather than cloud-based processing.

Rationale:
University labs often have poor connectivity, and transmitting images introduces privacy risks.

Impact:

- No images leave the user's device
- Improved responsiveness
- Compliance with Responsible AI and privacy principles

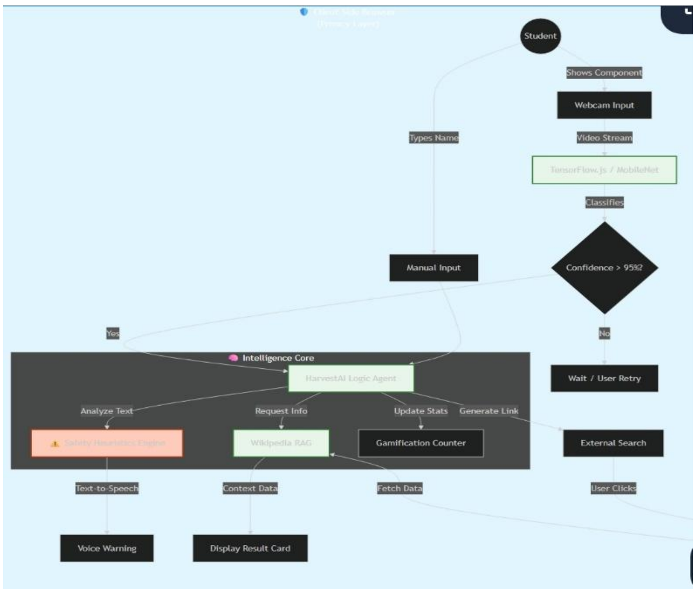

Figure 1: Client-side processing for privacy and safety

B. Retrieval-Based Knowledge vs. Static Databases

Decision:
Early prototypes used a fixed component database. This approach was replaced with API-based retrieval.

Rationale:
A static database limits scalability and quickly becomes outdated.

Impact:
Manual input allows users to explore components beyond the visual model's training scope while maintaining transparency about confidence and uncertainty.

C. Deterministic Safety Rules vs. Generative AI

Decision:
Safety recommendations are generated using rule-based heuristics rather than large language models.

Rationale:
Generative AI systems may hallucinate or vary responses, which is unacceptable in safety-critical contexts.

Impact:

- Consistent and predictable safety warnings
- Reduced ethical and physical risk
- Clear accountability in system behavior

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5. Prototype & Key Features

Feature 1: Safety-Aware Component Identification

Upon identifying a component, HarvestAI immediately evaluates potential risks and provides **audible and visual warnings** using Text-to-Speech (TTS). This design supports accessibility and ensures safety information is prioritized before reuse suggestions.

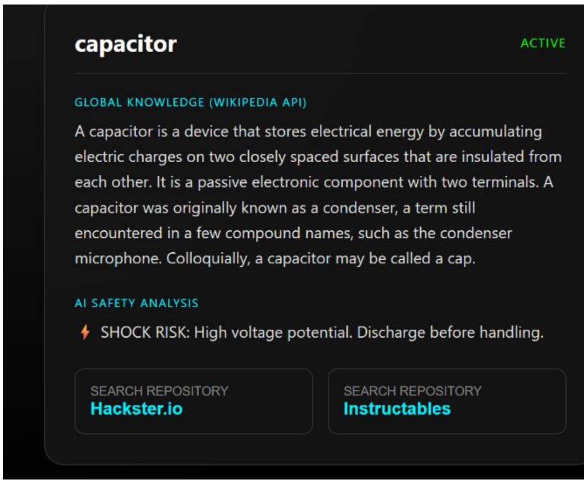

Figure 2: Safety warning displayed before reuse guidance.

Feature 2: Gamified Sustainability Impact Tracking

To encourage responsible behavior, the system displays **approximate indicators** of e-waste diverted and CO_2 emissions prevented. These metrics are intentionally framed as **awareness tools**, not precise environmental measurements.

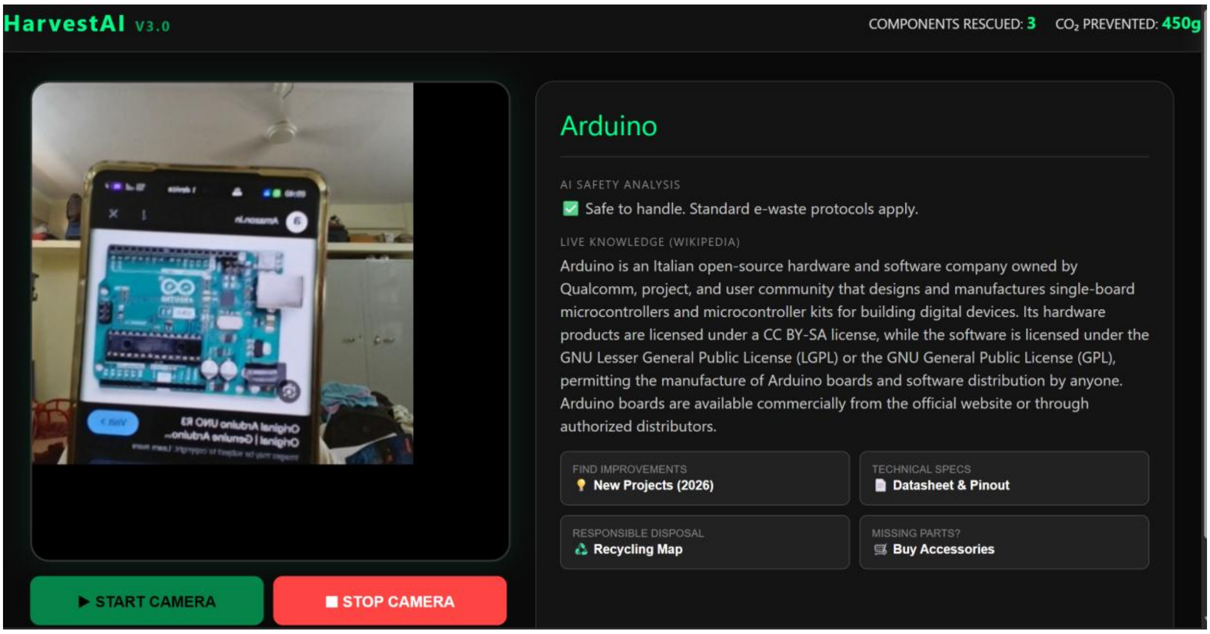

Figure 3: Real-time sustainability awareness indicators.

6. Responsible AI Considerations

This project explicitly incorporates Responsible AI principles:

- **Transparency:** The system provides guidance, not decisions. Final responsibility remains with the user.
- **Fairness:** The vision model was trained using varied lighting conditions to reflect real lab environments.
- **Safety:** Safety warnings are prioritized and can block further suggestions until acknowledged.
- **Privacy:** No images or personal data are stored or transmitted.

Disclaimer:
HarvestAI is an educational decision-support prototype and does not replace professional safety training or certified recycling procedures.

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7. Limitations & Future Scope

Current Limitations

- Visual similarity between certain boards (e.g., Arduino variants) may cause ambiguity.
- CO_2 metrics are approximate and used solely for engagement purposes.

Future Enhancements

- Integration of **OCR** to read IC part numbers directly.
- Campus-level component exchange platform to support a circular electronics economy.

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8. Conclusion

HarvestAI demonstrates that meaningful sustainability impact does not require complex or opaque AI systems. By combining lightweight computer vision, real-time information retrieval, and deterministic safety rules, the project transforms electronic waste into an educational resource while maintaining ethical responsibility. This approach highlights how AI can be applied thoughtfully to solve local, real-world sustainability challenges.
