SMART INDIA HACKATHON 2025

Problem Statement ID: SIH25036
Problem Statement Title:
Development of Sensor for Detection of Microplastics
Theme: Miscellaneous
PS Category: Hardware
Team ID:
Team Name: AI-Gyani

AI-Gyani

Development of Sensor for Detection Of Microplastics

SMART INDIA HACKATHON 2025

Proposed Solution:

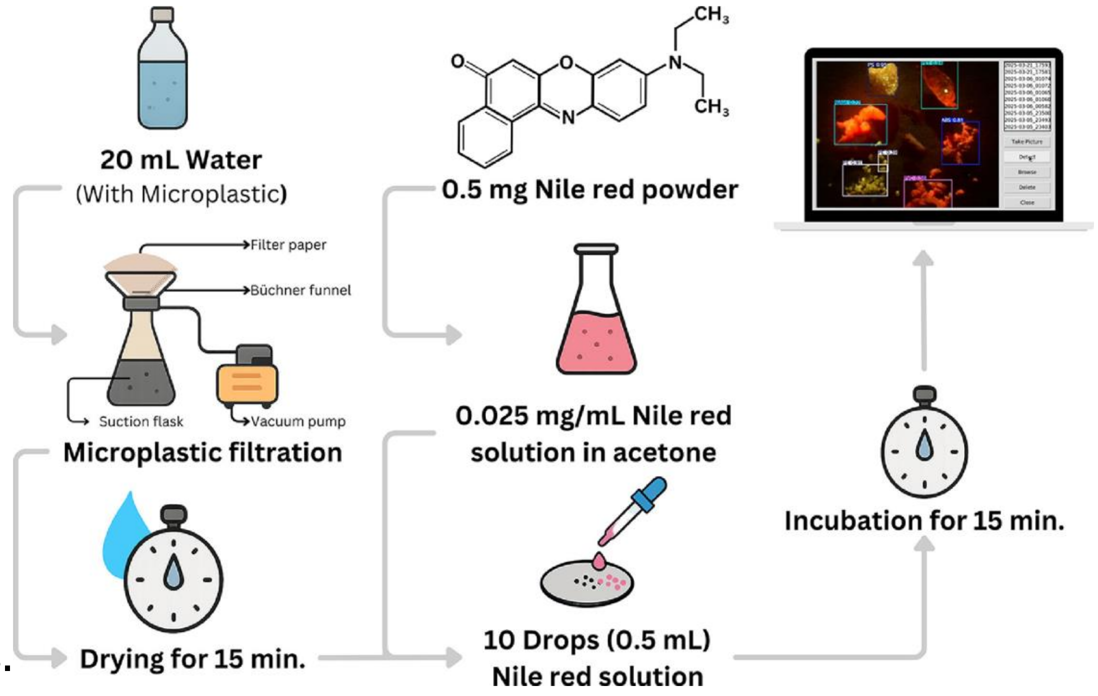
- Portable, low-cost, AI-driven microplastic detection device.
- Uses **Nile Red staining + UV excitation** and pre-trained **deep learning** architectures utilizing **transfer learning** for **segmentation-based** classification.
- **Improvements vs baseline research:**
  - Higher-resolution microscope will detect **smaller particles** also of range 20–50 µm vs 100 µm.
  - **Battery + solar power** for sustainable field use.

How it addresses the problem:

- Enables **real-time, field-deployable** detection.
- Reduces dependence on expensive lab-based spectroscopic techniques such as FTIR and Raman.
- Provides faster and more accessible monitoring for researchers & agencies.

Innovation & Uniqueness:

- To the best of our knowledge, this is a low-cost, solar-autonomous prototype.
- **Resolution upgrade** ensures higher precision.
- Integrated AI model customized for **colored & weathered plastics**.



AI-Gyani

TECHNICAL APPROACH

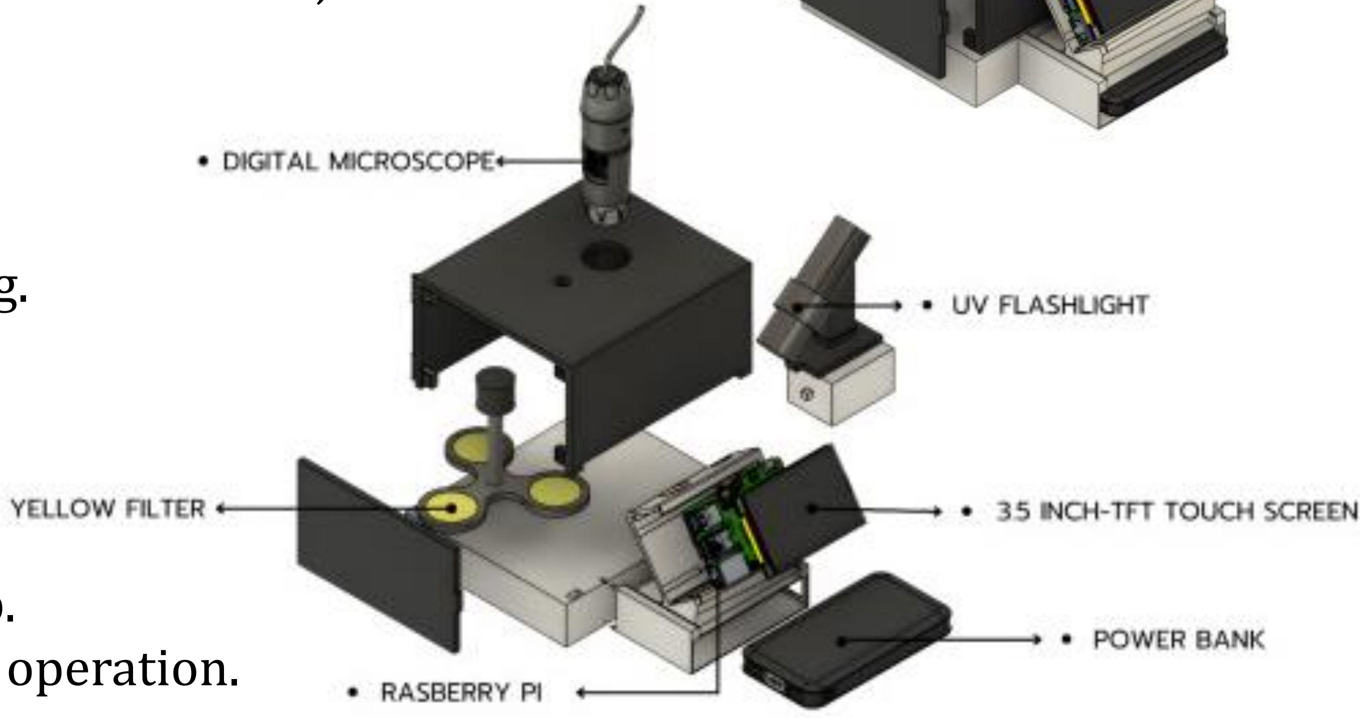
SMART INDIA HACKATHON 2025

Technologies:

- **Hardware:** Raspberry Pi 4/5, high-resolution microscope (≥8–12 MP), UV LEDs, optical filters, Battery pack, Solar panel, 3D printed housing.
- **Software/AI:** Python, OpenCV, Pretrained Transfer Model, Custom dataset, real-time inference pipeline.

Methodology / Flow:

- Sample preparation → Nile Red staining.
- UV excitation (395 nm) → fluorescence imaging.
- High-res microscope captures image.
- Preprocessing (HSV thresholding).
- Pretrained Transfer Model detects & classifies microplastics.
- Results displayed + logged via touchscreen app.
- Power system: battery + solar panel → full-day operation.



AI-Gyani

FEASIBILITY AND VIABILITY

SMART INDIA HACKATHON 2025

Feasibility:

- Baseline prototype validated in research (high accuracy, cost ≈ ₹30K).
- Our enhancement uses high-resolution sensors & solar kits.

Challenges:

- Creating a custom dataset that mimics real water samples.
- Microscope integration to make optimal design.
- Colored/weathered plastics reduce detection accuracy.

Strategies:

- For Custom Dataset Preparation
    - Store distilled water in old plastic bottles to induce microplastic leaching.
    - Use commercial bottled water samples (stored in sunlight and without sunlight).
    - Dissolve purchased microplastic powder in water for controlled samples.
- Model retrained with augmented dataset including weathered and dyed plastics for segmentation.

Parameter	Portable NR+ML Device	FTIR System	Raman System
One-Time Instrument Cost	₹ 30,000 - ₹55,000	₹30–58 lakh	₹57–130 lakh
Setup/Installation Time	<4 hours	2–4 weeks	2–4 weeks
Smallest Detectable Size	10µm (with upgraded scope)	≈10µm (FPA), 5µm (premium)	1µm (confocal premium)
Portability	Portable, field-use	Lab only	Lab only
Analysis Time per Sample	~20–60 seconds	15–60 minutes	15–60 minutes
Consumables per Test	₹8–10	₹31.6	₹35
Operator Skill Required	Low–moderate	High	Very High
Automated AI Analysis	Yes	No (manual validation)	No (manual validation)
Maintenance Cost/Year	≈₹2,000	≈₹25,000	≈₹50,000

AI-Gyani

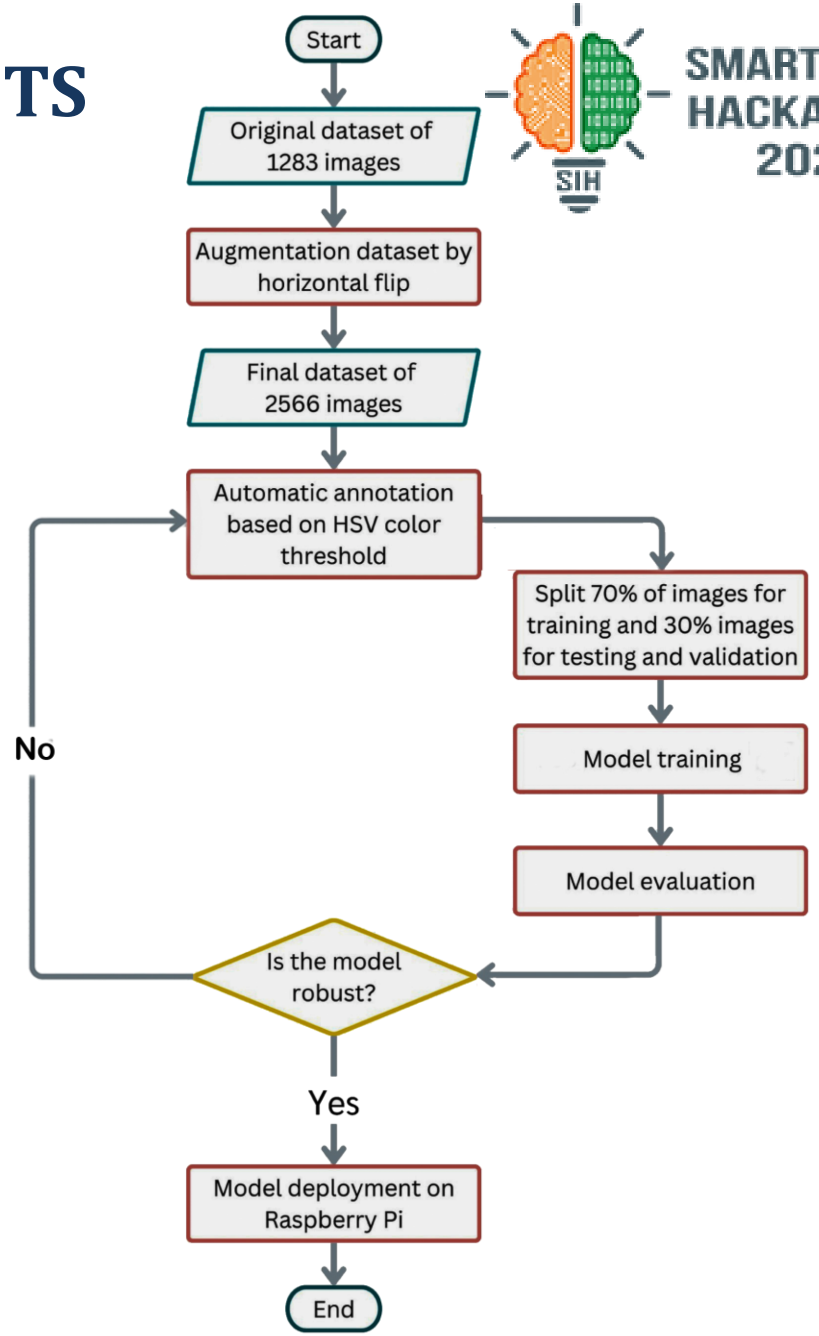
IMPACT AND BENEFITS

Impact:

- Empowers environmental monitoring agencies with **real-time, low-cost, deployable sensor**.
- Enables researchers to **quantify microplastics in field locations**.
- Supports government in **pollution tracking and policy enforcement**.

Benefits:

- **Social:** Safer water for communities.
- **Environmental:** Better tracking → stronger pollution control.
- **Economic:** Reduces reliance on expensive FTIR/Raman labs.
- **Sustainability:** Solar-powered, portable, low-energy solution.



SMART INDIA HACKATHON 2025

AI-Gyani

RESEARCH AND REFERENCES

SMART INDIA HACKATHON 2025

Reference:

- Rermborirak, K., Nanuan, P., Komonpan, P., & Sukpancharoen, S. (2025). Low-cost portable microplastic detection system integrating nile red fluorescence staining with YOLOv8-based deep learning. Journal of Hazardous Materials Advances, 19, 100787.
- Prasad, S., Bennett, A., & Triantafyllou, M. (2024). Characterization of Nile red-stained microplastics through fluorescence spectroscopy. Journal of Marine Science and Engineering, 12(8), 1403.

Additional Sources / Dataset links:

- *Stressor-AOP Network for plastic Additives*. (2025, September 10). https://cb.imsc.res.in/saopadditives/
- Nyadjro, E. S., Webster, J. a. B., Boyer, T. P., Cebrian, J., Collazo, L., Kaltenberger, G., Larsen, K., Lau, Y. H., Mickle, P., Toft, T., & Wang, Z. (2023). The NOAA NCEI marine microplastics database. Scientific Data, 10(1). https://doi.org/10.1038/s41597-023-02632-y
- Program, N. |. N. |. O. M. D. (n.d.). *Marine debris program.* https://marinedebris.noaa.gov/
- Sombsuk. (n.d.). *GitHub - sombsuk/dataset_microplastic*. GitHub. https://github.com/sombsuk/dataset_microplastic

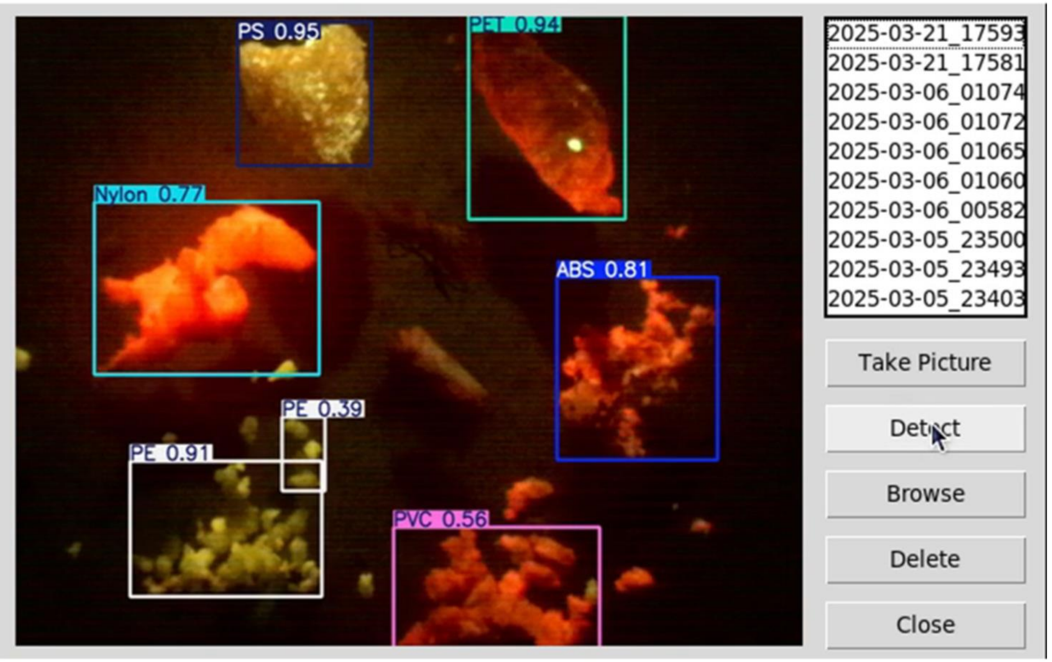


Image Ref: https://www.sciencedirect.com/science/article/pii/S2772416625001986