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ConfSort: Conformal Models for Plastic Waste Sorting

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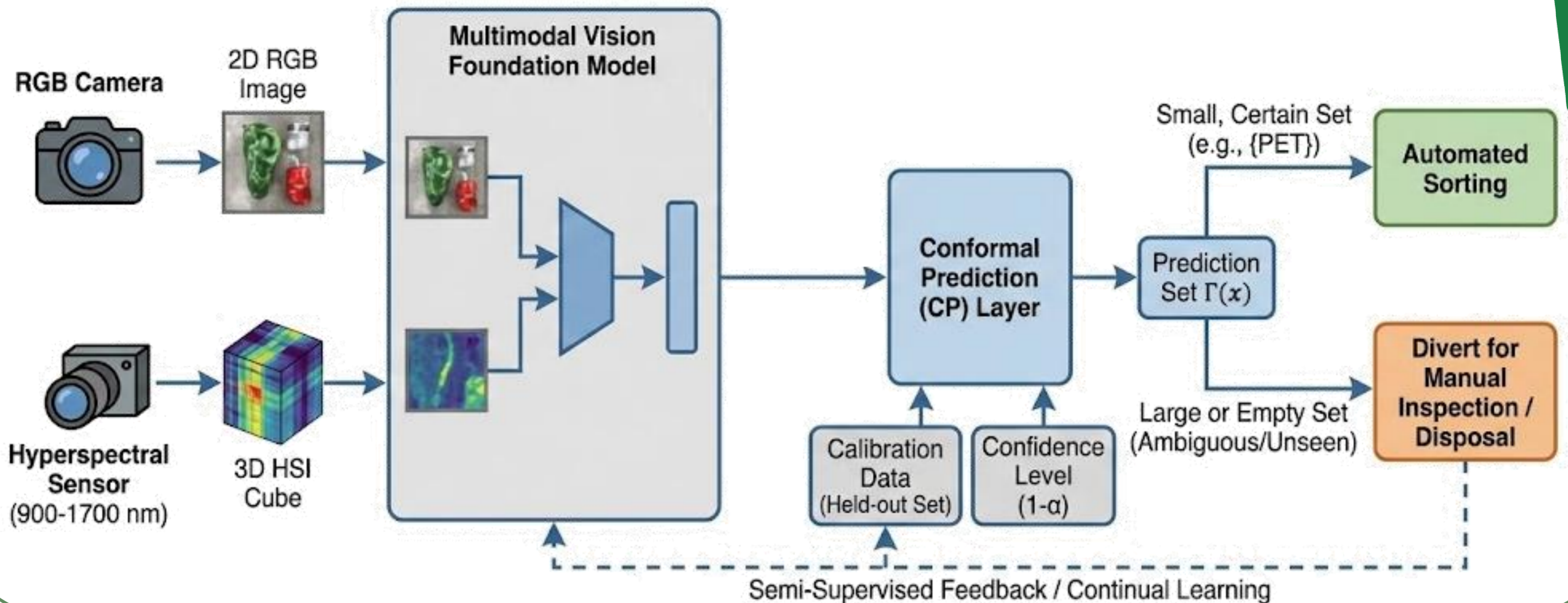
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1. The Challenge: Reliability for Plastic Waste Sorting [1]

- ❖ **Operational Risk** : Inability to identify transparent, black, or multi-polymer plastics.
- ❖ **Lack of Confidence** : Models are overconfident, forcing misclassifications on ambiguous items.
- ❖ **Limited Adaptability** : Difficulty adapting to new packaging designs without full retraining.

2. Proposed Methodology: Multimodal CP Architecture



3. Research Focus

Multimodal Foundation Models :

- ❖ Fuses RGB and HSI to learn generalizable representations across domains.
- ❖ Enables zero- or few-shot classification of new materials.

Conformal Prediction (CP) :

- ❖ Extends Inductive CP [2] to complex multimodal foundation models to safely flag low-confidence items for manual inspection.
- ❖ Builds on recent work regarding CP "beyond exchangeability" [3] to obtain coverage under spectral/material domain shift.

4. Expected Results

Case Type	Input Visual	Traditional AI Output (Softmax)	ConfSort Output (Prediction Set)	Result
Clear/Easy		<p>**PET (0.92)</p>	99% Confidence Set { PET }	Automated Sorting
Ambiguous		<p>**PP (0.55) (High risk of error)</p>	99% Confidence Set { PP, PE, PET }	Divert for Re-scan / Deferral
Domain Shift		<p>**HDPE (0.40) (Silent Failure)</p>	99% Confidence Set { } Alert: Empty Set	Manual Inspection / Reject

5. References

- [1] Maier, Georg, et al. "A survey of the state of the art in sensor-based sorting technology and research." IEEE access (2024).
- [2] Papadopoulos, Harris, et al. "Conformal prediction with neural networks." ICTAI (2007).
- [3] Barber, Rina Foygel, et al. "Conformal prediction beyond exchangeability." The Annals of Statistics (2023).

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