# PoTATO: A Dataset for Analyzing Polarimetric Traces of Afloat Trash Objects

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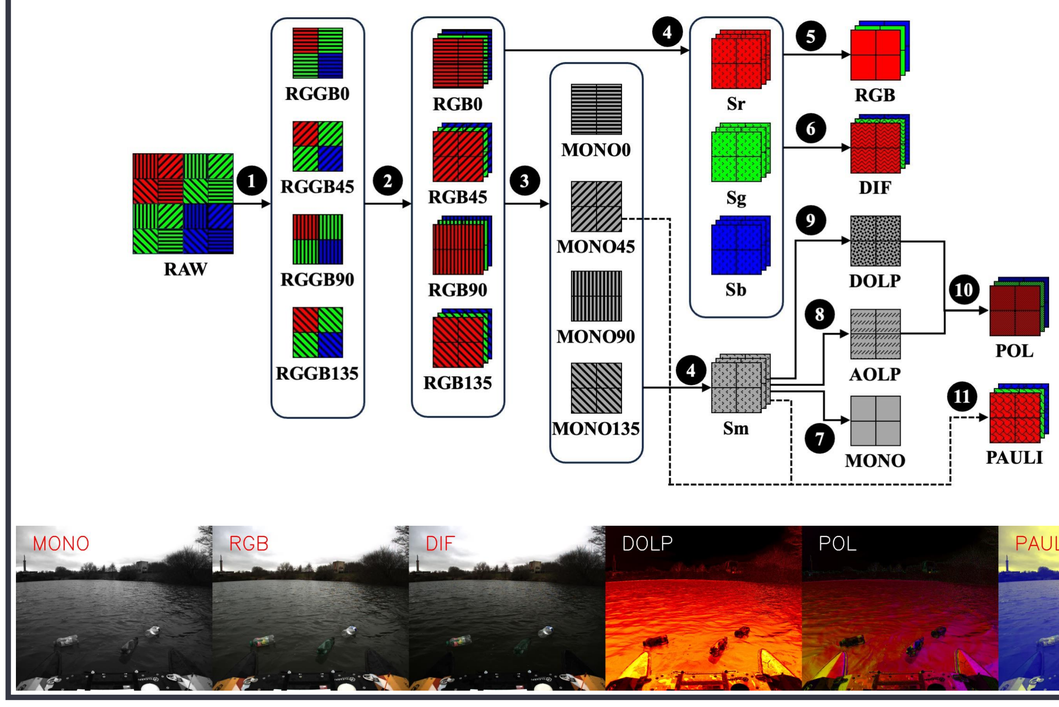
## Summary

- **Goal: Enhance waste detection on water surfaces by leveraging polarimetric imaging.**
- **Problem: Current object detection systems struggle with outdoor lighting conditions and water reflections.**
- **Contribution: Unique dataset with baselines for object detection and analysis of the effectiveness of polarimetric imaging in improving detection accuracy.**

## Methodology

**We extract 6 visualizations and set detection baselines with three models: Faster R-CNN, RetinaNet, and YOLO-v5.**

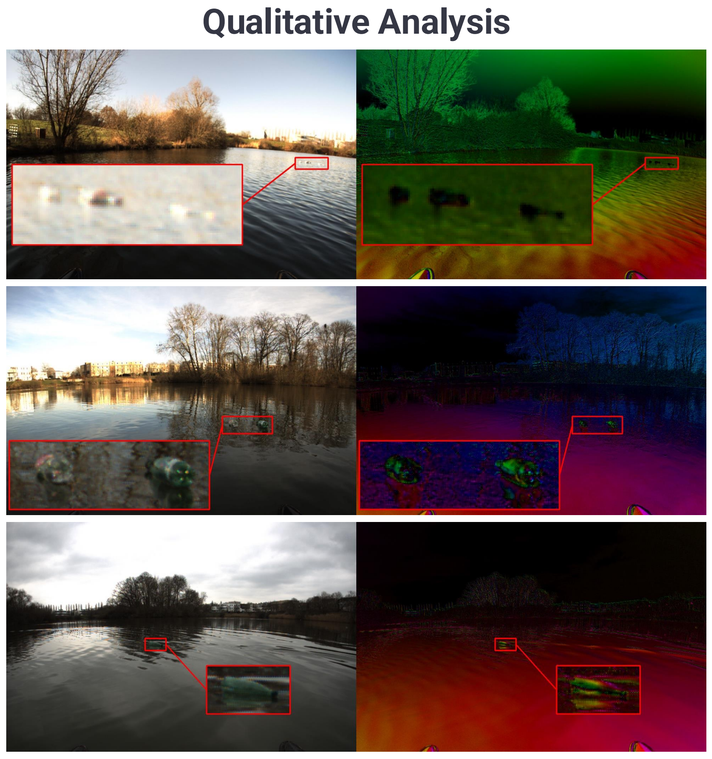



## Evaluation

| | Channel | AP | APs | APm | APl | ARs | ARm | ARl |
|---|---|---|---|---|---|---|---|---|
| Yolo-v5 m | MONO | 0.009 | 0.000 | 0.008 | 0.150 | 0.000 | 0.001 | 0.155 |
| | RGB | 0.019 | 0.000 | 0.025 | 0.350 | 0.000 | 0.022 | 0.383 |
| | DIF | **0.025** | 0.000 | **0.055** | **0.412** | 0.000 | **0.052** | **0.440** |
| | DOLP | 0.009 | 0.000 | 0.000 | 0.025 | 0.000 | 0.000 | 0.021 |
| | POL | 0.005 | 0.000 | 0.004 | 0.017 | 0.000 | 0.001 | 0.017 |
| | PAULI | 0.010 | 0.000 | 0.008 | 0.126 | 0.000 | 0.007 | 0.125 |

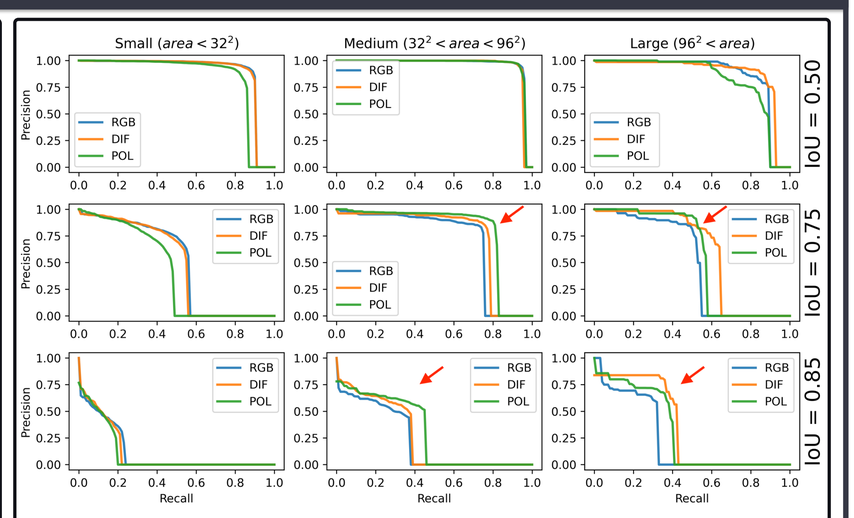
**Pre-trained models show reduced performance**

### Qualitative Analysis




| | Channel | AP | APs | APm | APl | ARs | ARm | ARl |
|---|---|---|---|---|---|---|---|---|
| Faster R-CNN | MONO | 0.448 | 0.416 | 0.555 | 0.465 | 0.476 | 0.617 | 0.493 |
| | RGB | **0.482** | **0.446** | 0.599 | 0.483 | **0.504** | 0.651 | 0.531 |
| | DIF | 0.477 | 0.434 | 0.609 | **0.550** | 0.492 | 0.658 | **0.609** |
| | DOLP | 0.418 | 0.357 | 0.592 | 0.486 | 0.424 | 0.646 | 0.539 |
| | POL | 0.428 | 0.361 | **0.627** | 0.506 | 0.426 | **0.678** | 0.579 |
| | PAULI | 0.446 | 0.411 | 0.557 | 0.497 | 0.468 | 0.622 | 0.529 |
| RetinaNet | MONO | 0.362 | 0.309 | 0.512 | 0.481 | 0.424 | 0.593 | 0.520 |
| | RGB | **0.394** | **0.323** | 0.564 | 0.523 | **0.449** | 0.633 | 0.562 |
| | DIF | 0.388 | 0.303 | 0.593 | **0.537** | 0.423 | 0.653 | 0.575 |
| | DOLP | 0.321 | 0.229 | 0.560 | 0.503 | 0.352 | 0.631 | 0.558 |
| | POL | 0.345 | 0.244 | **0.597** | 0.506 | 0.367 | **0.655** | **0.584** |
| | PAULI | 0.368 | 0.304 | 0.537 | 0.468 | 0.419 | 0.610 | 0.496 |
| Yolo-v5 m | MONO | 0.402 | 0.381 | 0.500 | 0.376 | 0.466 | 0.592 | 0.455 |
| | RGB | **0.461** | **0.431** | 0.578 | 0.457 | **0.517** | 0.662 | 0.528 |
| | DIF | 0.459 | 0.425 | 0.589 | **0.574** | 0.509 | 0.662 | **0.632** |
| | DOLP | 0.400 | 0.357 | 0.560 | 0.464 | 0.442 | 0.633 | 0.566 |
| | POL | 0.429 | 0.386 | **0.597** | 0.391 | 0.478 | **0.674** | 0.527 |
| | PAULI | 0.450 | 0.418 | 0.572 | 0.379 | 0.504 | 0.669 | 0.453 |

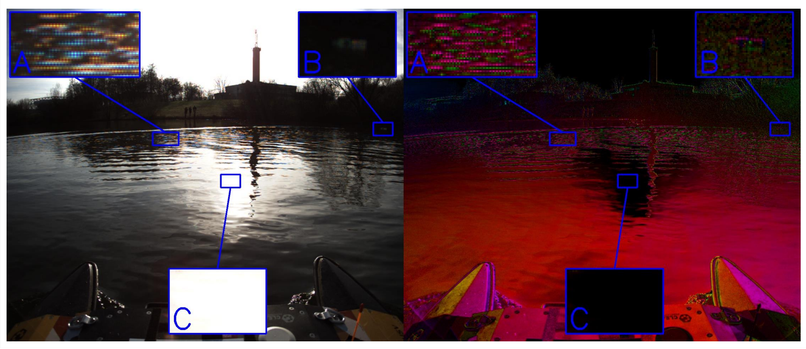
- **Fine-tuning enhances precision of all models and for all channels.**
- **DIF channel, combining chromatic and polarimetric data, performs best overall.**
- **POL channel, based solely on polarimetric data, often outperforms RGB for medium objects.**
- **RGB excels for small object detection.**




**Precision-recall curves show POL and DIF achieve higher precision on medium and large objects.**

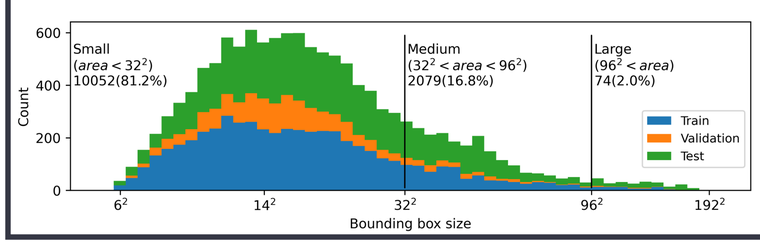
### Challenges:

**A: artifacts; B: small objects; C: saturation**




## Dataset

- **Unique dataset providing RAW polarimetric images captured with TRI050S1-QC (IMX264MY) sensor.**
- **Variable weather conditions and points of view.**




| Day | Images | Labels | Weather |
|---|---|---|---|
| 01 | 27 | 81 | Sunny |
| 02 | 114 | 414 | Sunny |
| 03 | 462 | 1450 | Sunny |
| 04 | 1658 | 4392 | Sunny |
| 05 | 902 | 2096 | Partially Cloudy |
| 06 | 459 | 787 | Cloudy |
| 07 | 978 | 3160 | Cloudy |
| | 4600 | 12380 | |

## Conclusion

- **Polarimetric images are capable of outperforming chromatic images for the object detection task in regions with heightened polarization properties.**
- **Future research: Development of novel approaches for fusing color and polarization modalities to enhance perception.**

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