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Motivation and Approach



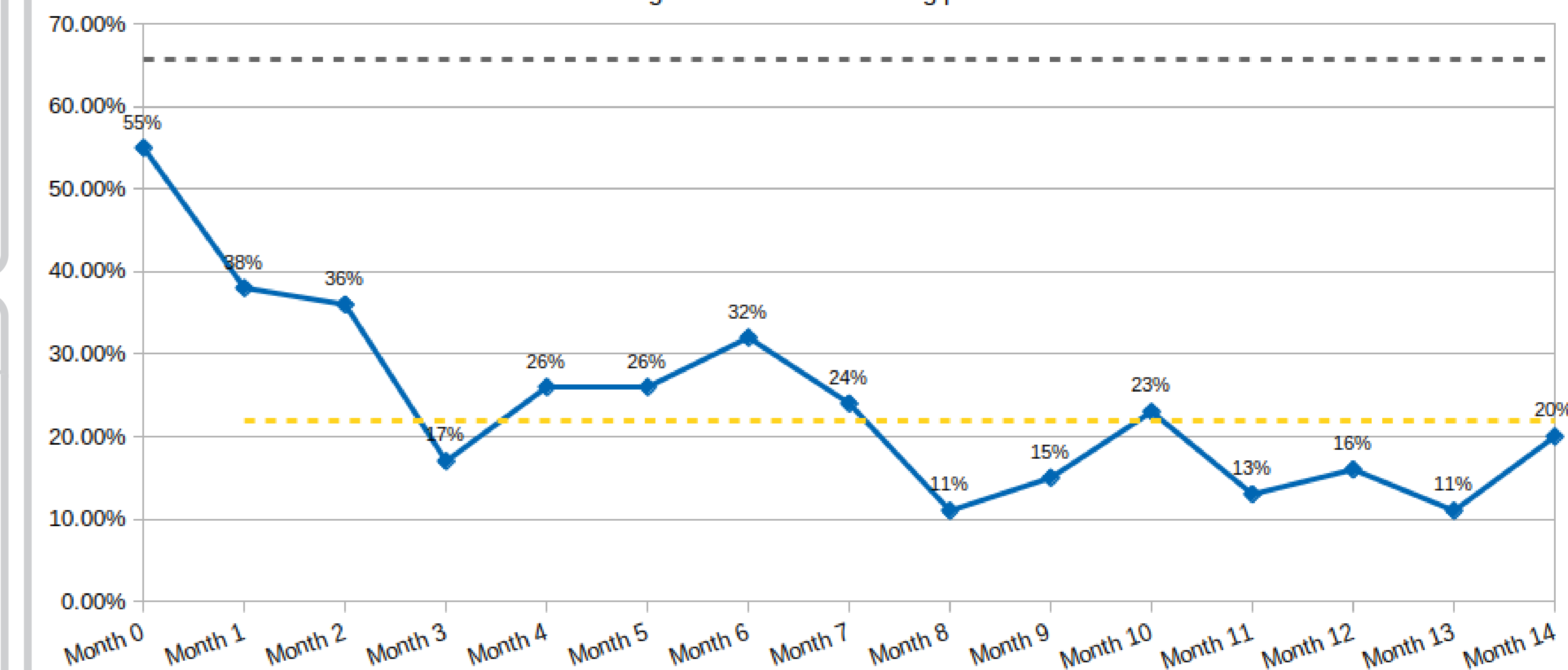
- Modern garbage truck equipped with complex hardware.
 - Multiple modalities: **rgb**, **stereo** and **multispectral** cameras.
 - **GSM module** for localization
 - Rugged and sealed **metal casing**.
- SOTA image recognition software deployed in the cloud.
 - **Secure** connection for safe data transfer.
 - **Scalable** cloud orchestration depending on workload.
 - **AI** model with human-like performance.
- Direct feedback to the households for change in behavior.
 - **App** or **SMS** notifications.
 - **Informative** text about the waste distribution along with hints on how to improve.
 - **Long-time monitoring** for improved community waste management.

Results

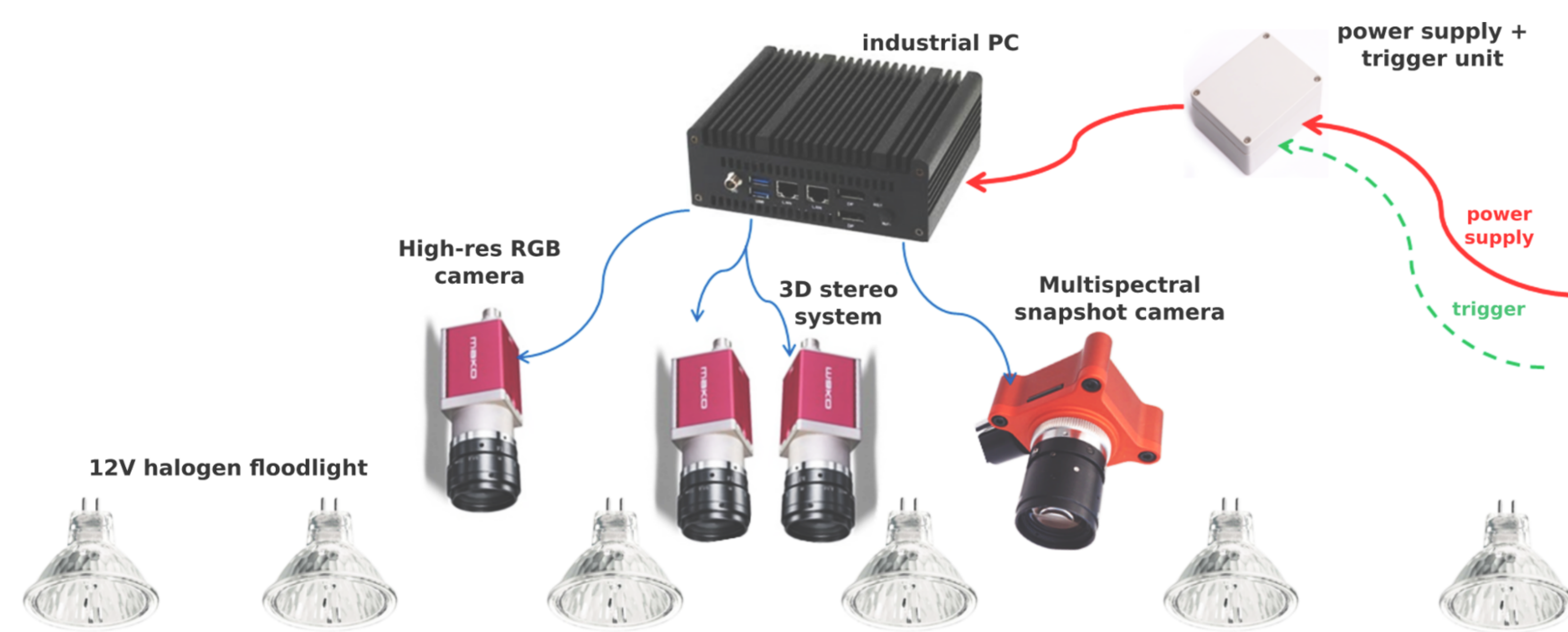
Accuracy (ACC) and Intersection-over-Union (IOU) metrics for the test set.
^w indicates weighting by covered area instead of averaging over all classes equally.

class	ACC	IOU
background	98.35 ± 3.62	96.03 ± 5.15
organic	56.86 ± 35.91	53.24 ± 33.64
garbage_bag	68.42 ± 28.26	54.66 ± 26.24
paper	50.36 ± 28.77	40.13 ± 24.69
pet	35.61 ± 25.80	27.56 ± 20.60
plastic	49.97 ± 22.05	38.81 ± 18.80
residual	67.26 ± 26.01	40.32 ± 22.71
average	53.36 ± 26.55	43.84 ± 25.41
average ^w	82.77 ± 14.06	77.22 ± 13.93

Proportion of contaminants in residual waste during a 14 months monitoring period



Hardware



Custom-designed hardware system with external trigger.

- **RGB camera:** High resolution rgb camera for capturing details in shape and appearance.
- **Multispectral camera:** Multi-channel camera in visible spectrum and near-infrared for capturing information in extended wavelength ranges.
- **Stereo system:** Two grayscale cameras for depth perception.
- **Halogen floodlights:** For uniform illumination across the recorded area.
- **Industrial PC:** Recording unit capable to work in vibrating and temperature-critic environments.

Datasets

Dataset of 3000+ labeled images collected over 14 months.

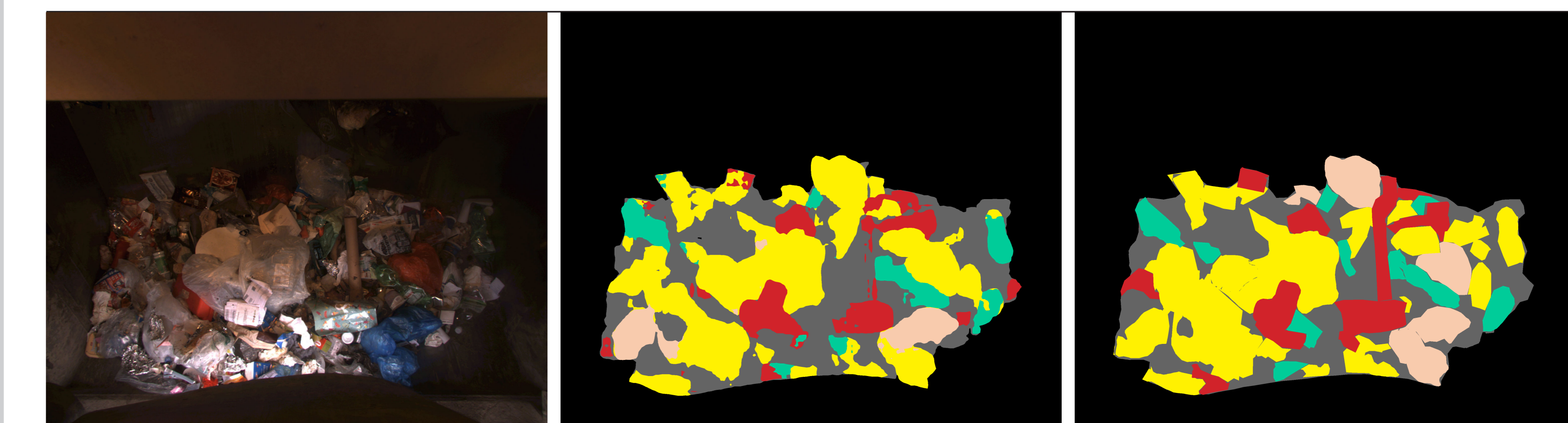
- Manual segmentation labels collected for **3107 images** (2908 train, 60 val, 139 test).
- **Collection over more than 14 months** to incorporate seasonal fluctuations.
- **6 dominant waste categories:** *organic*, *garbage_bag*, *paper*, *PET*, *plastic* and *residual*.

class	img count	img area (mean±std) [%]	img area range [%]
background	2908/2908	71.67 ± 9.77	0.61 – 93.86
ignore	1882/2908	2.68 ± 5.65	0.00 – 67.06
organic	956/2908	1.79 ± 4.27	0.00 – 39.39
garbage_bag	2364/2908	6.92 ± 5.42	0.00 – 49.07
paper	2449/2908	2.04 ± 2.39	0.00 – 18.85
pet	1787/2908	0.62 ± 0.77	0.00 – 9.67
plastic	2844/2908	6.57 ± 5.33	0.00 – 33.91
residual	2908/2908	11.85 ± 5.29	5.02 – 58.13

a) train

background	139/139	68.85 ± 10.21	39.03 – 100.00
ignore	72/139	1.78 ± 2.16	0.00 – 10.21
organic	96/139	19.84 ± 16.05	0.03 – 58.46
garbage_bag	93/139	6.39 ± 5.31	0.05 – 23.51
paper	82/139	3.10 ± 2.83	0.04 – 13.99
pet	59/139	0.87 ± 0.89	0.08 – 4.77
plastic	90/139	6.46 ± 5.08	0.05 – 32.46
residual	112/139	7.30 ± 6.47	0.00 – 35.78

b) test



Input

CNN Prediction

Ground Truth

Acknowledgments

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