Automatic universal taxonomies for multi-domain semantic segmentation

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Overview

- We construct universal taxonomies in a fully automatic fashion through iterative dataset integration.
- Our method automatically detects class relations based on visual similarity.
- We achieve competitive peformance on single-domain and multi-domain dataset collections.

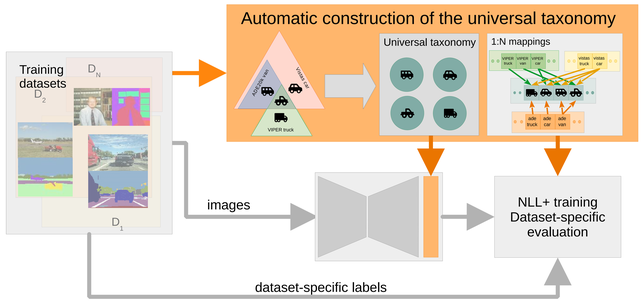
Challenge: Incompatible dataset taxonomies

(a) Overlapping classes

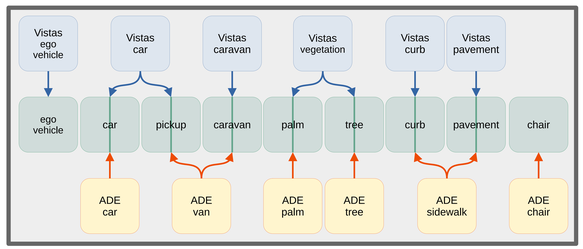
(b) Discrepant granularity

(c) Incompatibilites between VIPER (top) and Vistas (bottom). Middle: Viper truck intersects Vistas car at pickups. Right: VIPER road is a union of Vistas line marking, Vistas manhole etc.

Contributions

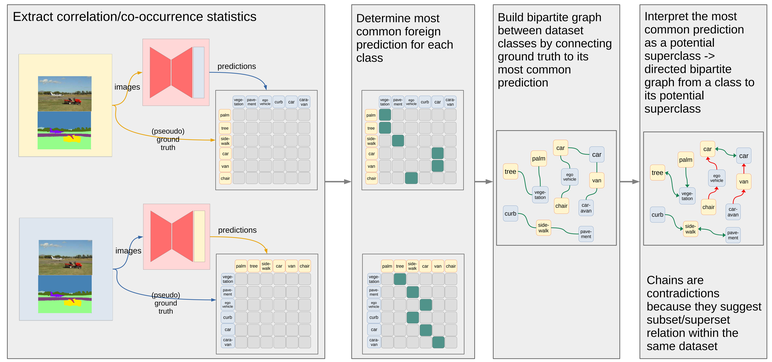


(a) Automated creation of universal taxonomy and class mappings. Universal taxnomy defines visual concepts present in a colleecton of datasets, mappings allow us to express datasets-specific classes as unions of universal classes.

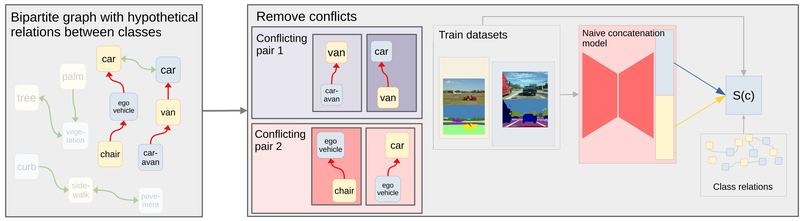


(b) Discover relations between datasets to construct the universal taxonomy. If two classes are related they share a visual concept. The shared visual concept becomes a universal class.

Method: Hypothesize relations



Method: Resolve conflicts

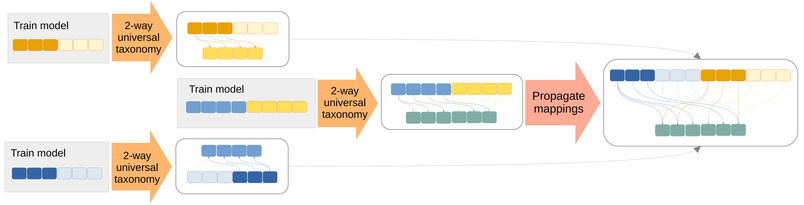


- Naive concatenation baseline treats datasets-specific labels as unrelated during training.
- Naive concatenation can be used to extract co-occurrence/coincidence statistics.
- Improved naive concatenation inference looks at relations between classes:

$$S(c) = P(c) + \sum_{q \cap c \neq \emptyset} P(q)$$

- Split chains into pairs of conflicting hypohteses and use $S(c)$ to compare them.
- Base the universal taxonomy on the winning set of hypotheses.

Method: Merge more than two datasets



- Blend taxonomies iteratively.

Experiments: ADE-Vistas

- Automatic taxonomy outperforms the baseline and is competitive with manual universal taxonomy.

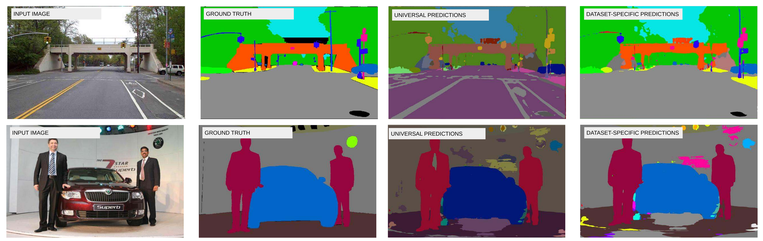
Taxonomy	#	evals	ADE	Vistas
naive concat	215	N/A	36.8	41.1
manual univ.	186	N/A	37.4	42.7
auto univ. (concat, co-occurrence)	178	24	37.4	42.8

Experiments: MSeg dataset collection

- MSeg [2]: a custom taxonomy which relabels 194 classes and merges 100 labeled classes.

Taxonomy	#	evals	ADE	BDD	City	COCO	IDD	SUN	Vistas
naive concat.	469	N/A	27.0	55.6	69.0	29.8	51.3	37.4	33.7
manual univ. [1]	294	N/A	31.0	58.5	72.6	35.4	54.4	41.7	39.1
MSeg original	194	N/A	23.3	59.4	72.6	30.3	42.6	40.2	26.1
auto univ.	243	164	30.7	59.6	72.7	35.6	55.2	42.3	35.8

Qualitative results



Conclusion

- Proof of concept for automatic construction of universal taxonomies.
- A degree of interpretability of the universal model due to hierarchical connections across taxonoimes
- Competitive results with respect to alternative approaches

References

[1] Petra Bevandić, Marin Oršić, Ivan Grubišić, Josip Šarić, and Siniša Šegvić. Multi-domain semantic segmentation with overlapping labels. In *WACV*, 2022.

[2] John Lambert, Zhuang Liu, Ozan Sener, James Hays, and Vladlen Koltun. Mseg: A composite dataset for multi-domain semantic segmentation. In *CVPR*, 2020.

Acknowledgement

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