Scaling Novel Object Detection with Weakly Supervised Detection Transformers

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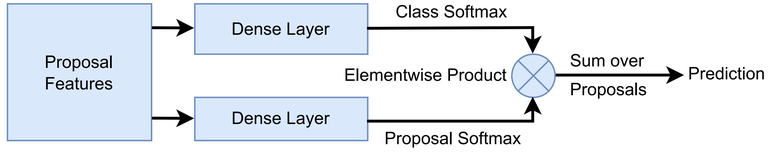
Effortless Detection of Novel Objects

- Object detection annotation is expensive and difficult
- ***Weakly supervised object detection*** (WSOD) uses only class labels
- Pretrain on fully-annotated source dataset, then transfer knowledge to target dataset of novel objects with image-level class labels
- ***Goal: effortless detection of novel objects without labeling***

Pretrain Finetune Predict

Previous Work

- Primary WSOD paradigm is ***multiple instance learning*** (MIL)
  - Aggregates class features over dataset to localize objects
  - 2016: Bilen and Vedaldi introduced deep learning framework for MIL [1]



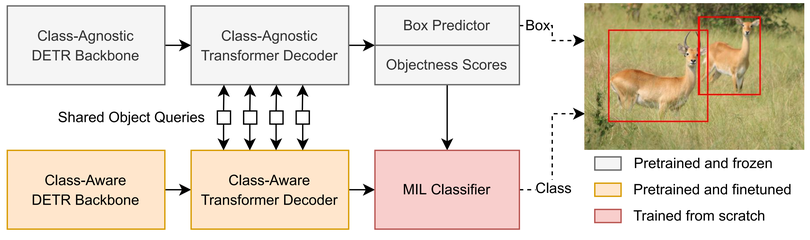
- Current approaches are ***not scalable***
  - Require multiple rounds of training and refinement [3, 5, 8]
  - Optimized for datasets with only 60 pretraining and 20 novel classes

Our Contributions

- We propose Weakly Supervised Detection Transformer which ***scales to 1000s of novel classes with a single pretrain-finetune step***
- We introduce new large-scale experimental setups for WSOD and call for the community to move beyond toy datasets to complex settings
- We also identify and rectify a weakness of a standard regularization method and explore sparsity for proposal noise reduction

Weakly Supervised Detection Transformer

- Combines proposal generation of two-stage CNN model with scalability and simplicity of one-stage Transformer approach



Large-Scale Novel Object Detection Results

- We utilize FSOD dataset [4] with 800 pretraining and 200 novel classes (175K boxes) constructed from ILSVRC and Open Images
  - ***Classes maximally separated*** w.r.t. semantic hierarchy
  - 4X the pretraining classes and 2X the novel classes than shown previously

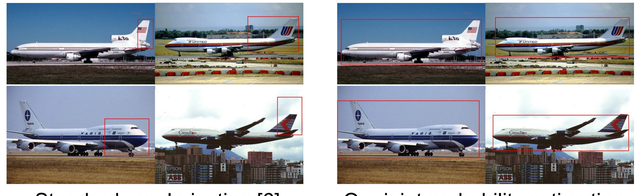
Method	mAP	AP50	mAR
Zhong *et al.* [8]	20.6	32.7	34.4
WS-DETR Base	13.9	20.0	60.1
WS-DETR Sparse	28.5	**38.5**	**68.0**
WS-DETR Joint	**28.6**	37.8	65.3
WS-DETR Full	**28.6**	38.2	67.4
Supervised DETR [2]	47.7	64.0	76.3

- We study iNaturalist dataset [7] for species detection (560K boxes)
  - 13 superclasses and ***2,854 subclasses—5X that of Open Images***
  - Less "pure" of a novel classes setting than FSOD, but realistic

Method	13 Superclasses		2,854 Subclasses	
	mAP	AP50	mAP	AP50
Zhong *et al.* [8]	44.1	76.7	-	-
WS-DETR Base	0.2	0.4	1.7	3.7
WS-DETR Sparse	**61.1**	**79.3**	30.4	38.2
WS-DETR Joint	54.8	70.0	22.1	29.8
WS-DETR Full	60.7	78.7	**35.4**	**43.5**
Supervised DETR [2]	79.2	93.6	51.5	58.8

Joint Probability Estimation

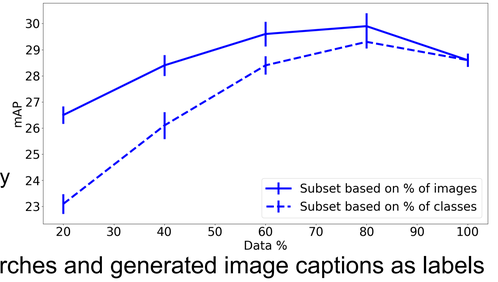
- We show a standard regularization technique [8] ***overfits to classification features*** [5] and we introduce a solution
- Uses pretrained "objectness" for joint probability of object and class



Standard regularization [6] Our joint probability estimation

Scaling Study

- Can't pretrain two DETRs? No problem! Using the class-agnostic DETR in classification stream only drops performance by 1.6 mAP
- First large-scale rigorous study of WSOD scaling: ***class quantity is more important than image quantity*** [4, 6]
  - Current benchmark datasets an order of magnitude too small
  - Takeaway: Dataset construction should prioritize class diversity



Future Work

- Use noisy Web searches and generated image captions as labels
- Use Transformer attention to refine box predictions [3]
- Integrate self-supervised detection-aware pretraining [9]

References

[1] Bilen and Vedaldi. Weakly Supervised Deep Detection Networks. *CVPR*, 2016.
[2] Carion *et al.* End-to-End Object Detection with Transformers. *ECCV*, 2020.
[3] Huang *et al.* Comprehensive Attention Self-Distillation for WSOD. *NeurIPS*, 2020.
[4] Fan *et al.* Few-Shot Object Detection with Attention-RPN and Multi-Relation Detector. *CVPR*, 2020.
[5] Tang *et al.* Multiple Instance Detection Network with Online Instance Classifier Refinement. *CVPR*, 2017.
[6] Uijlings *et al.* Revisiting Knowledge Transfer for Training Object Class Detectors. *CVPR*, 2018.
[7] Van Horn *et al.* The iNaturalist Species Classification and Detection Dataset. *CVPR*, 2018.
[8] Zhong *et al.* Boosting WSOD with Progressive Knowledge Transfer. *ECCV*, 2020.
[9] Zhong *et al.* DAP: Detection-Aware Pre-training with Weak Supervision. *CVPR*, 2021.