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Semi-Supervised Active Learning with Temporal Output Discrepancy

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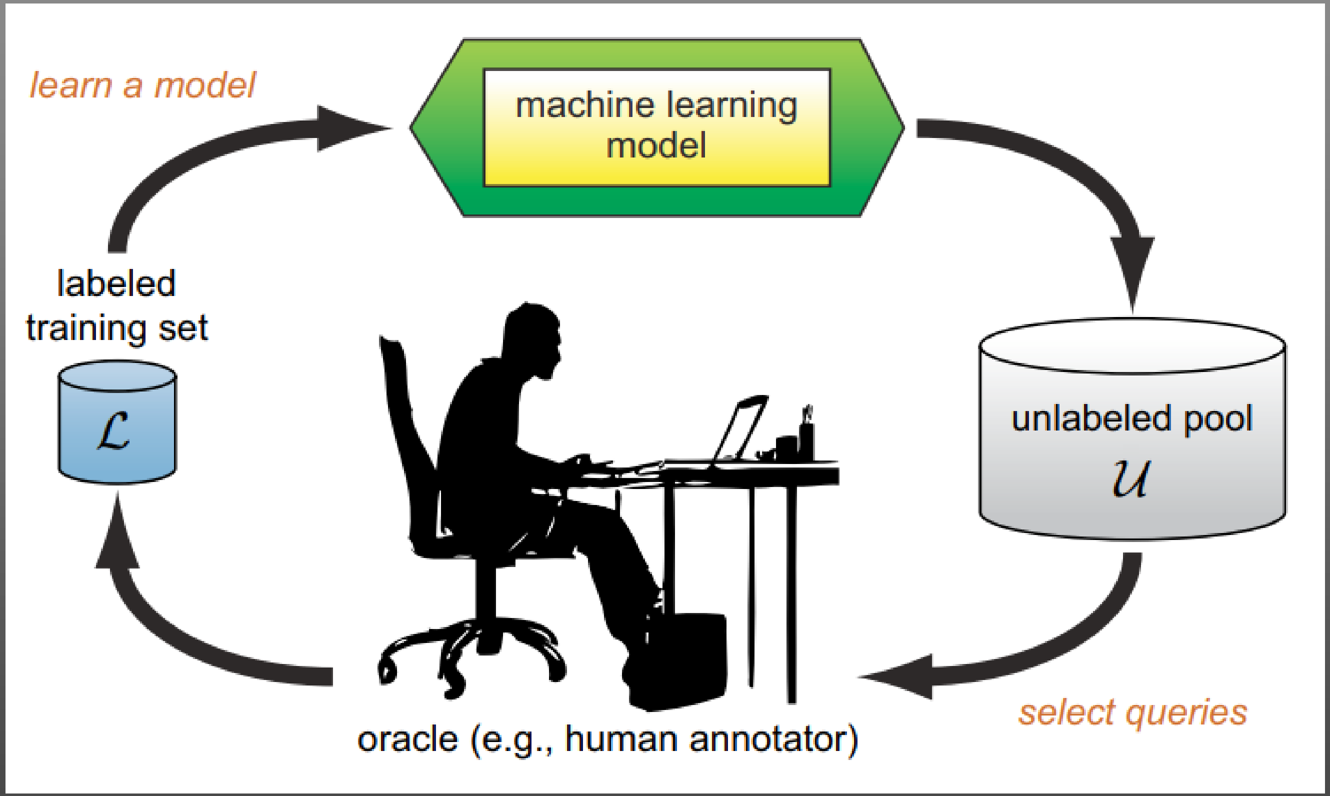
Active Learning



Settles 2010

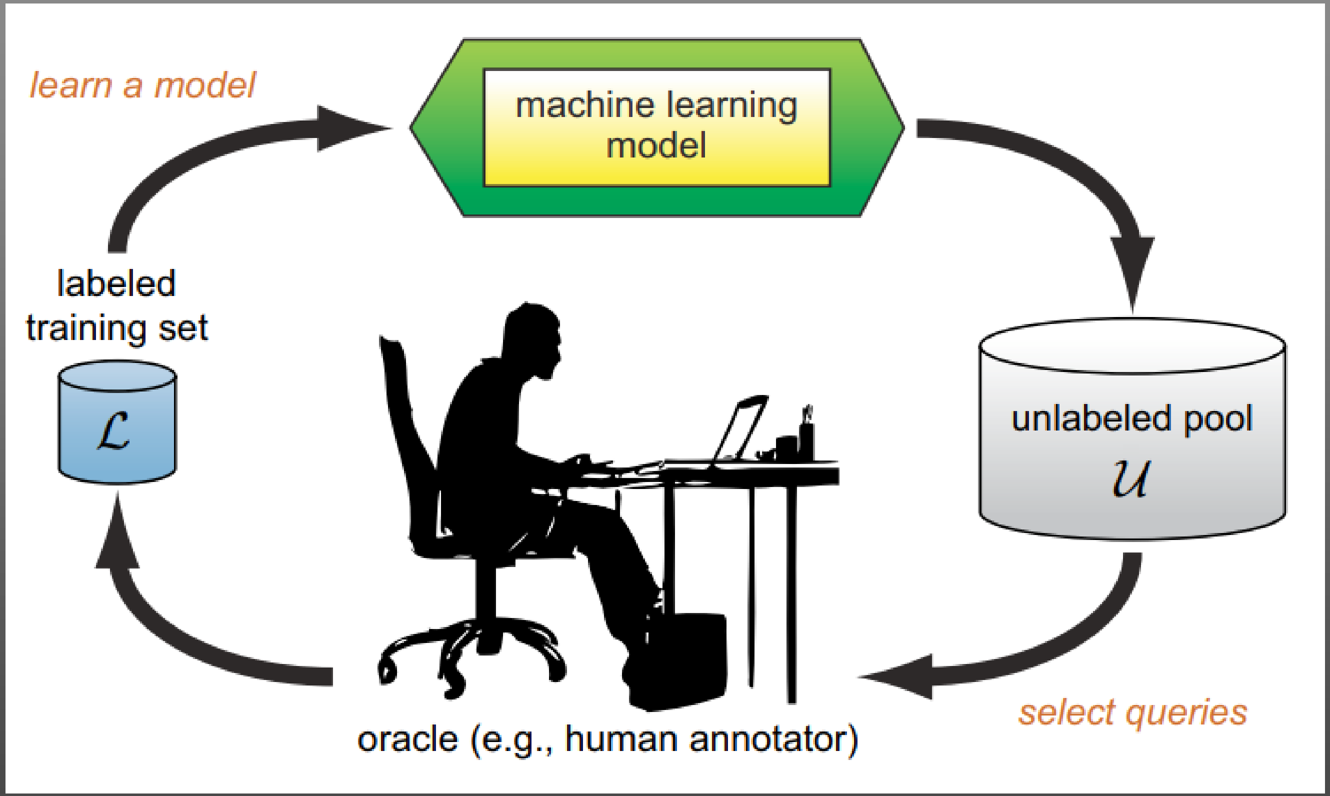
Diversity-aware Approaches

Uncertainty-aware Approaches

- *Margin between posterior probabilities*
- *Entropy of posterior probabilities*
- *Expected model change*
- *Expected error reduction*
- *Distance to decision boundary*
- *Adversarial discrimination*

Hybrid Methods

Active Learning



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Hybrid Methods

Loss Estimation via *Temporal Output Discrepancy (TOD)*

- Temporal Output Discrepancy (TOD):

  The discrepancy of outputs of a neural network *f* at different GD steps.

$$D_t^{\{T\}}(x) \overset{\text{def}}{=} \|f(x; w_{t+T}) - f(x; w_t)\|$$

Why can TOD estimate sample loss?

With an appropriate setting of learning rate η, we have

- **Theorem 1**

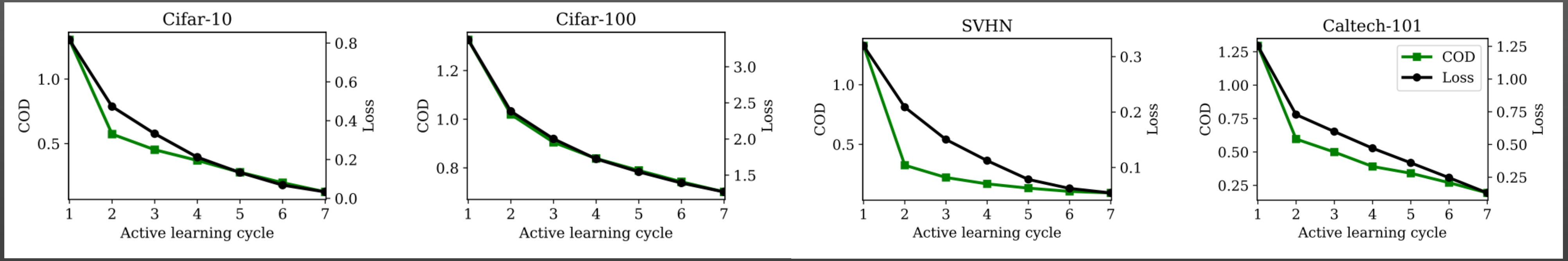
$$D_t^{\{1\}}(x) \leq \eta\sqrt{2L_t(x)}\|\nabla_w f(x; w_t)\|^2$$

- **Corollary 2**

$$D_t^{\{T\}}(x) \leq \sqrt{2T}\eta C \sqrt{\sum_{\tau=t}^{t+T-1} L_\tau(x)}.$$

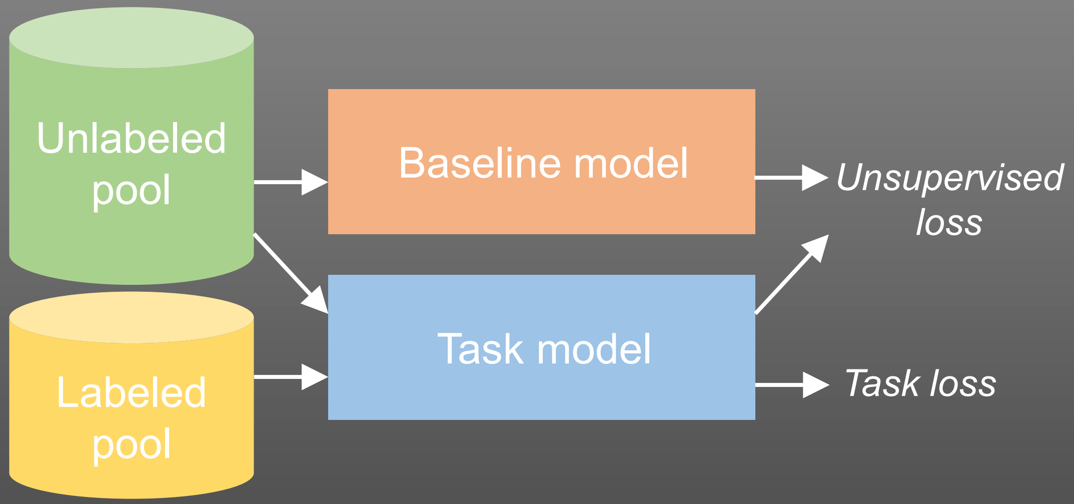
TOD-based Active Learning

- Cyclic Output Discrepancy (COD) as data sampling strategy



TOD-based Active Learning

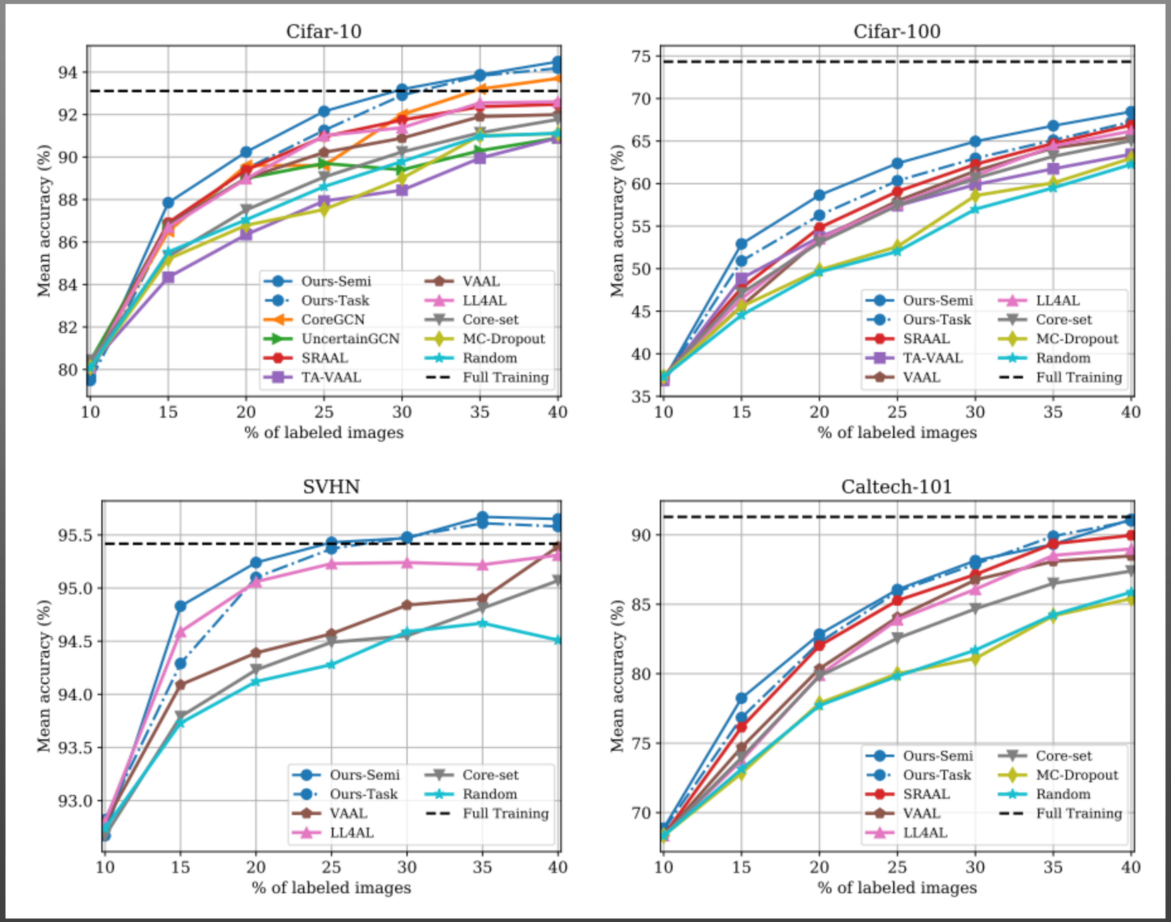
- Semi-supervised task training



Baseline model

Mean Teacher [Tarvainen and Harri, NeurIPS 2017]
The exponential moving average of historical model parameters

Experimental Comparison of Active Learning Methods



Active learning performance on four datasets

	Cifar10	**SVHN**	**Caltech-101**	Extra model?
Coreset (*ICLR'18*)	91.4s	168.7s	48.2s	×
VAAL (*ICCV'19*)	13.0s	17.2s	32.6s	√
LL4AL (*CVPR'19*)	7.7s	10.8s	39.6s	√
Ours	**7.2s**	**10.1s**	**26.9s**	×

Efficiency of active sampling strategies
(One active sampling iteration)

Summary

- Temporal Output Discrepancy (TOD) estimates the loss of unlabeled samples by evaluating the discrepancy of neural network outputs at different GD steps.
- TOD is a lower-bound of accumulated sample loss.
- Based on TOD, we develop an unlabeled data sampling strategy (COD) and a semi-supervised training scheme for active learning.

https://github.com/siyuhuang/TOD