

Estimating Instance-dependent Bayes-label Transition Matrix using a Deep Neural Network

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Motivation

- It is difficult to collect and annotate large-scale data.
- Cheap data collection and labeling methods involve noisy labels.

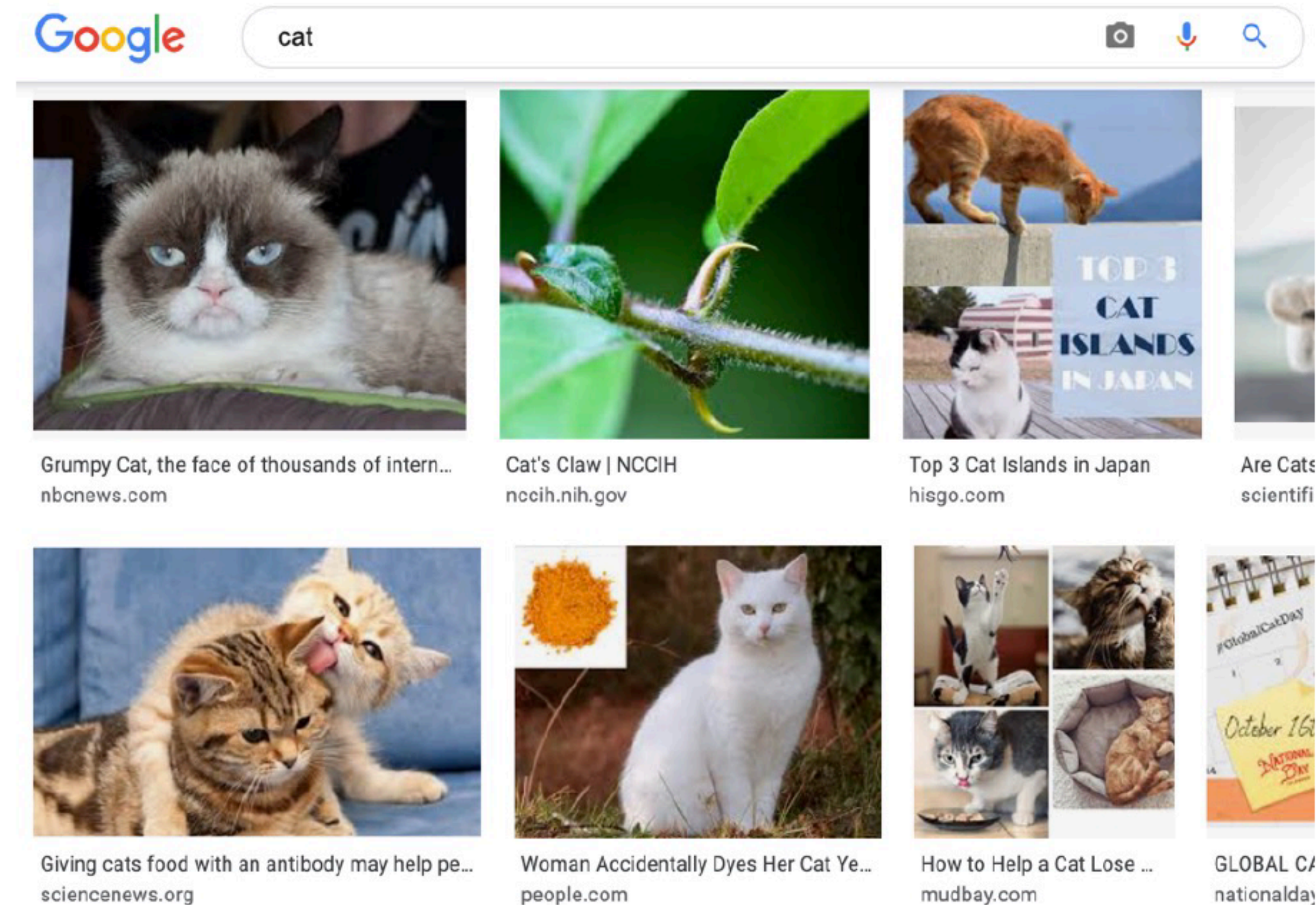


Fig.1: Label noise from web search.

Noise patterns

- Random classification noise (RCN):

$$T_{i,j}(\mathbf{x}) = P(\tilde{Y} = j \mid Y = i, \mathbf{x}) = c$$

- Class-conditional label noise (CCN):

$$T_{i,j}(\mathbf{x}) = P(\tilde{Y} = j \mid Y = i, \mathbf{x}) = P(\tilde{Y} = j \mid Y = i)$$

- Instance-dependent label-noise (IDN):

$$T_{i,j}(\mathbf{x}) = P(\tilde{Y} = j \mid Y = i, \mathbf{x})$$

CLTM v.s. BLTM

- Instance-dependent Clean-Label Transition Matrix (CLTM):

$$T_{i,j}(\mathbf{x}) = P(\tilde{Y} = j \mid Y = i, \mathbf{x})$$

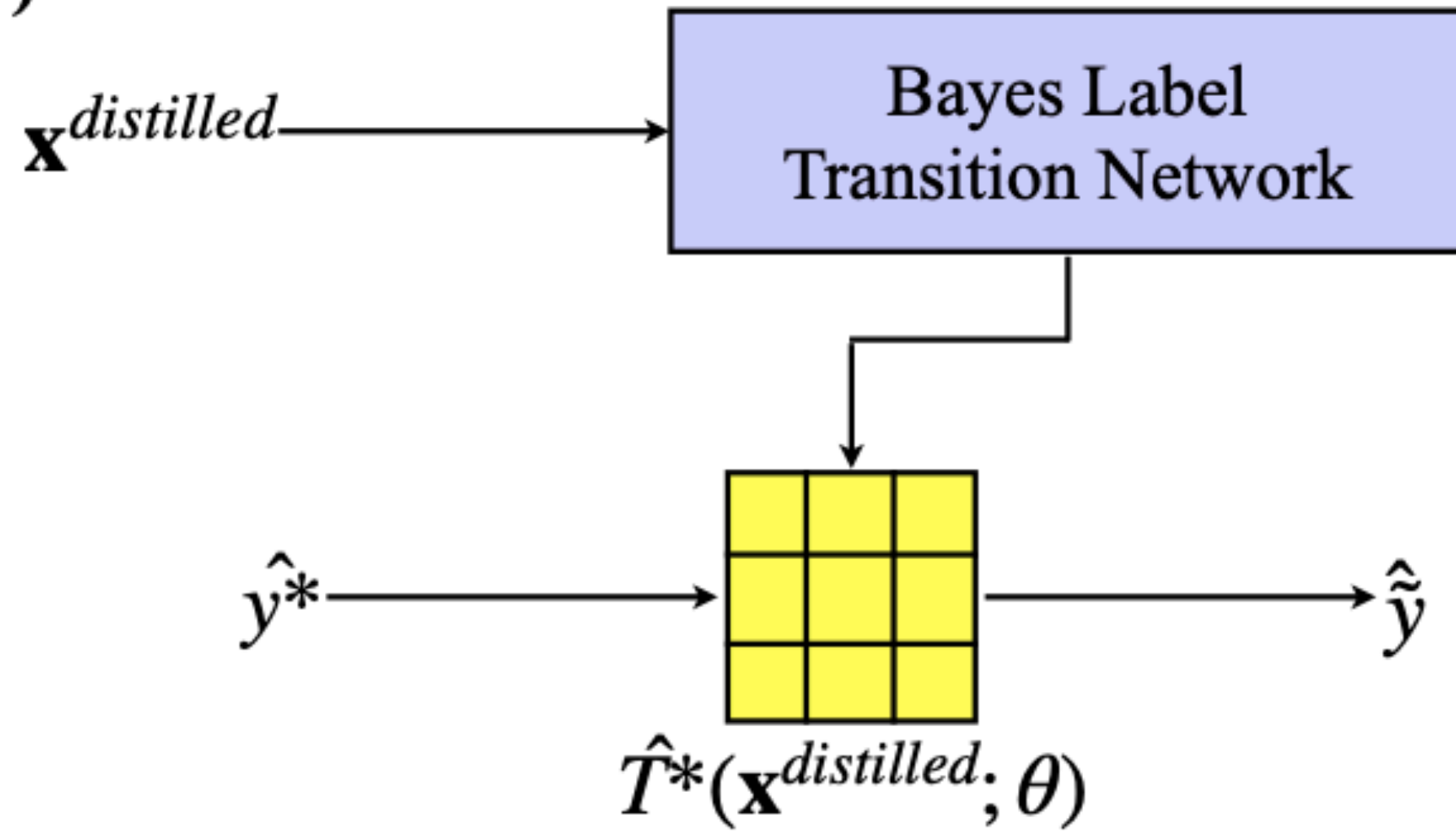
- Instance-dependent Bayes-Label Transition Matrix (BLTM):

$$T_{i,j}^*(\mathbf{x}) = P(\tilde{Y} = j \mid Y^* = i, \mathbf{x})$$

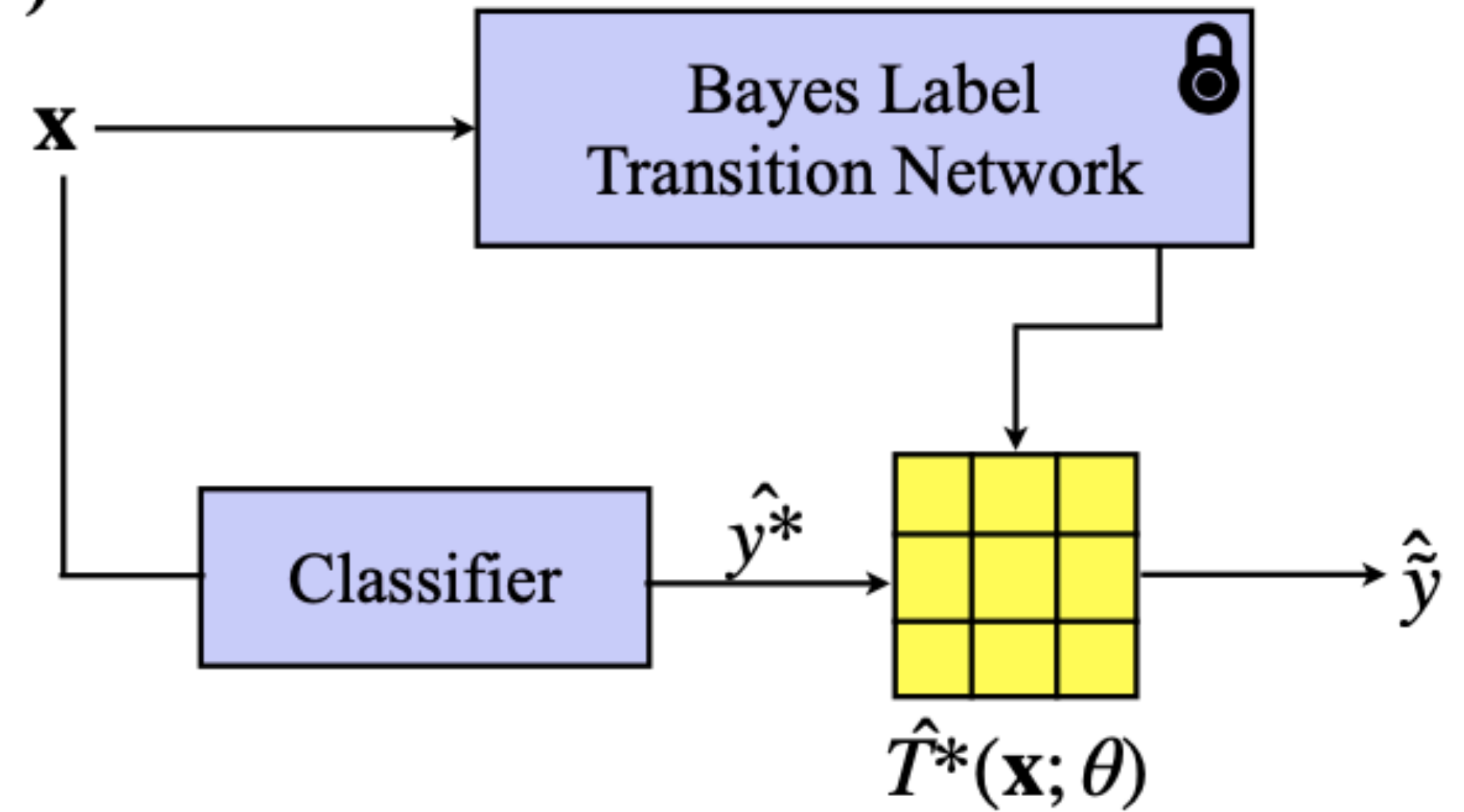
The Bayes labels can be directly inferred from the noisy class posterior [1]
and are less uncertain.

Bayes Label Transition Network

(a)



(b)



$$\hat{R}_1(\theta) = -\frac{1}{m} \sum_{i=1}^m \tilde{\mathbf{y}}_i \log(\hat{\mathbf{y}}_i^* \cdot \hat{T}^*(\mathbf{x}_i^{distilled}; \theta))$$

$$\hat{R}_2(w) = -\frac{1}{n} \sum_{i=1}^n \tilde{\mathbf{y}}_i \log(f(\mathbf{x}_i; w) \cdot \hat{T}^*(\mathbf{x}_i; \theta))$$

Performance on SVHN

	IDN-10%	IDN-20%	IDN-30%	IDN-40%	IDN-50%
CE	90.39 $\pm$ 0.13	89.04 $\pm$ 1.32	85.65 $\pm$ 1.84	79.94 $\pm$ 2.71	61.01 $\pm$ 5.41
GCE	90.82 $\pm$ 0.15	89.35 $\pm$ 0.94	86.43 $\pm$ 0.63	81.66 $\pm$ 1.58	54.77 $\pm$ 0.25
APL	71.78 $\pm$ 0.76	89.48 $\pm$ 1.67	83.46 $\pm$ 2.17	77.90 $\pm$ 2.31	55.25 $\pm$ 3.77
Decoupling	90.55 $\pm$ 0.83	88.74 $\pm$ 0.77	85.03 $\pm$ 1.63	83.36 $\pm$ 2.73	56.76 $\pm$ 1.87
MentorNet	90.28 $\pm$ 0.52	89.09 $\pm$ 0.95	85.89 $\pm$ 0.73	82.63 $\pm$ 1.73	55.27 $\pm$ 4.14
Co-teaching	91.05 $\pm$ 0.33	89.56 $\pm$ 1.77	87.75 $\pm$ 1.37	84.92 $\pm$ 1.59	59.56 $\pm$ 2.34
Co-teaching+	92.83 $\pm$ 0.87	90.73 $\pm$ 1.39	86.37 $\pm$ 1.66	75.24 $\pm$ 3.77	54.58 $\pm$ 3.46
Joint	88.39 $\pm$ 0.62	85.37 $\pm$ 0.44	81.56 $\pm$ 0.43	78.98 $\pm$ 2.98	59.14 $\pm$ 3.22
DMI	92.11 $\pm$ 0.49	91.63 $\pm$ 0.87	86.98 $\pm$ 0.36	81.11 $\pm$ 0.68	63.22 $\pm$ 3.97
Forward	90.01 $\pm$ 0.78	89.77 $\pm$ 1.54	86.70 $\pm$ 1.44	80.24 $\pm$ 2.77	57.57 $\pm$ 1.45
Reweight	91.06 $\pm$ 0.19	92.01 $\pm$ 1.04	87.55 $\pm$ 1.71	83.79 $\pm$ 1.11	55.08 $\pm$ 1.25
S2E	92.70 $\pm$ 0.51	92.02 $\pm$ 1.54	88.77 $\pm$ 1.77	83.06 $\pm$ 2.19	65.39 $\pm$ 2.77
T-Revision	93.07 $\pm$ 0.79	92.67 $\pm$ 0.88	88.49 $\pm$ 1.44	82.43 $\pm$ 1.77	67.64 $\pm$ 2.57
PTD	93.77 $\pm$ 0.33	92.59 $\pm$ 1.07	89.64 $\pm$ 1.98	83.56 $\pm$ 2.21	71.57 $\pm$ 3.32
BLTM	96.05 $\pm$ 0.32	94.97 $\pm$ 0.58	93.99 $\pm$ 1.24	87.67 $\pm$ 1.29	78.13 $\pm$ 4.62
BLTM-V	96.37 $\pm$ 0.77	95.12 $\pm$ 0.40	94.69 $\pm$ 0.24	88.13 $\pm$ 3.23	78.71 $\pm$ 4.37

Performance on CIFAR-10

	IDN-10%	IDN-20%	IDN-30%	IDN-40%	IDN-50%
CE	73.54 $\pm$ 0.14	71.49 $\pm$ 1.35	67.52 $\pm$ 1.68	58.63 $\pm$ 4.92	51.54 $\pm$ 2.70
GCE	74.24 $\pm$ 0.89	72.11 $\pm$ 0.43	69.31 $\pm$ 0.18	56.86 $\pm$ 0.92	53.44 $\pm$ 1.28
APL	71.12 $\pm$ 0.19	68.89 $\pm$ 0.27	65.17 $\pm$ 0.35	53.22 $\pm$ 2.21	47.31 $\pm$ 1.41
Decoupling	73.91 $\pm$ 0.37	74.23 $\pm$ 1.18	70.85 $\pm$ 1.88	54.73 $\pm$ 1.02	52.04 $\pm$ 2.09
MentorNet	74.93 $\pm$ 1.37	73.59 $\pm$ 1.29	72.32 $\pm$ 1.04	57.85 $\pm$ 1.88	52.96 $\pm$ 1.98
Co-teaching	75.49 $\pm$ 0.47	75.93 $\pm$ 0.87	74.86 $\pm$ 0.42	59.07 $\pm$ 1.03	55.62 $\pm$ 3.93
Co-teaching+	74.77 $\pm$ 0.16	75.14 $\pm$ 0.61	71.92 $\pm$ 2.13	59.15 $\pm$ 0.87	53.02 $\pm$ 3.34
Joint	75.97 $\pm$ 0.98	76.45 $\pm$ 0.45	75.93 $\pm$ 1.65	63.22 $\pm$ 5.37	55.84 $\pm$ 3.25
DMI	74.65 $\pm$ 0.13	73.49 $\pm$ 0.88	73.93 $\pm$ 0.34	60.22 $\pm$ 3.47	54.35 $\pm$ 2.28
Forward	72.35 $\pm$ 0.91	70.98 $\pm$ 0.32	66.53 $\pm$ 1.96	58.63 $\pm$ 1.25	52.33 $\pm$ 1.65
Reweight	73.55 $\pm$ 0.32	71.49 $\pm$ 0.57	68.76 $\pm$ 0.37	60.32 $\pm$ 1.03	52.03 $\pm$ 1.70
S2E	75.93 $\pm$ 1.01	75.53 $\pm$ 0.32	71.21 $\pm$ 2.51	64.62 $\pm$ 0.68	56.03 $\pm$ 1.07
T-Revision	74.01 $\pm$ 0.45	73.42 $\pm$ 0.64	71.15 $\pm$ 0.43	59.93 $\pm$ 1.33	55.67 $\pm$ 2.07
PTD	76.33 $\pm$ 0.38	76.05 $\pm$ 1.72	75.42 $\pm$ 1.33	65.92 $\pm$ 2.33	56.63 $\pm$ 1.88
BLTM	81.73 $\pm$ 0.56	80.26 $\pm$ 0.63	77.69 $\pm$ 1.37	71.96 $\pm$ 2.27	59.15 $\pm$ 3.11
BLTM-V	82.16 $\pm$ 1.01	80.37 $\pm$ 1.98	78.82 $\pm$ 1.07	72.93 $\pm$ 4.00	60.33 $\pm$ 5.29