



Generalized Category Discovery with Decoupled Prototypical Network

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code: <https://github.com/Lackel/DPN>



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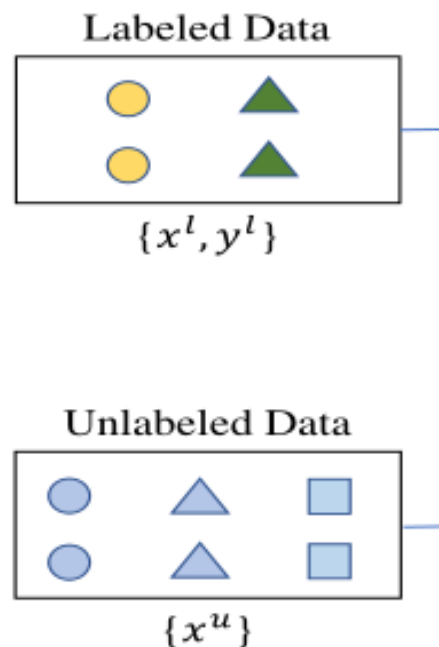
Reported by Zhaoze Gao



- 1. Introduction**
- 2. Approach**
- 3. Experiments**



Generalized Category Discovery



limitation

- Without considering differences between known and novel categories, current methods learn about them in a coupled manner, which can hurt model's generalization and discriminative ability.
- the coupled training approach prevents these models transferring category-specific knowledge explicitly from labeled data to unlabeled data, which can lose high-level semantic information and impair model performance.

Introduction

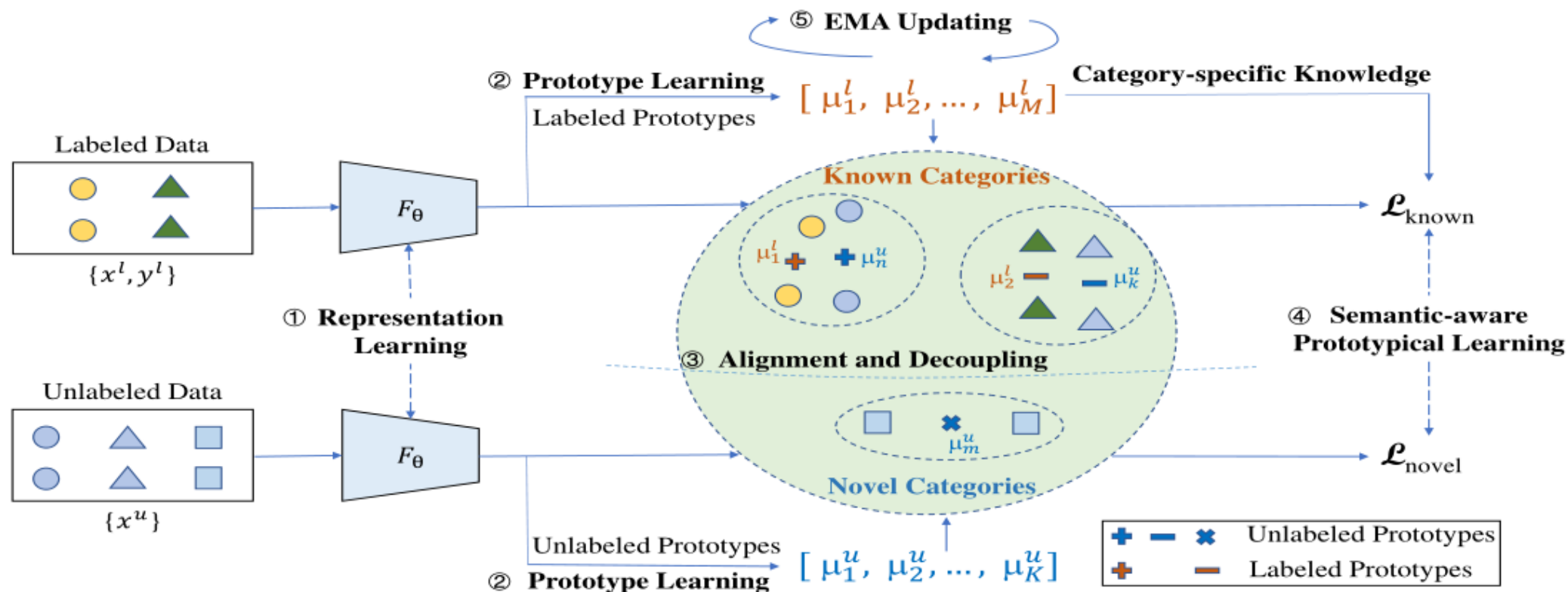


Figure 1: An overview of our model.

Approach

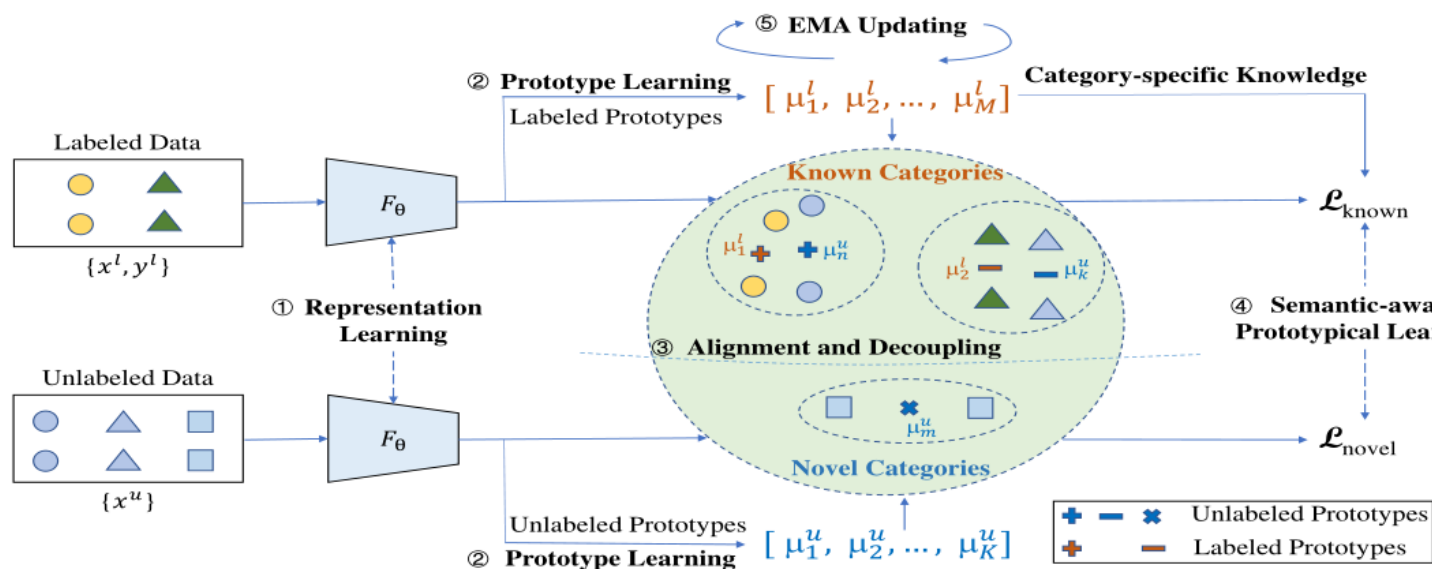


Figure 1: An overview of our model.

$$\mathcal{L}_{pre} = \mathcal{L}_{ce}(\mathcal{D}^l) + \mathcal{L}_{mlm}(\mathcal{D}^l, \mathcal{D}^u) \quad (1)$$

$$\bar{F}_\theta : \mathcal{X} \rightarrow \mathbb{R}^d.$$

$$P^l = \{\mu_j^l\}_{j=1}^M \quad \mu_j^l = \frac{1}{|C_j|} \sum_{x_i \in C_j} F_\theta(x_i)$$

$$M = |\mathcal{Y}_k| \quad C^u = \{C_1^u, C_2^u, \dots, C_K^u\}$$

$$K = |\mathcal{Y}_k| + |\mathcal{Y}_n|$$

$$P^u = \{\mu_j^u\}_{j=1}^{\bar{K}}, \text{ where } \mu_j^u = \frac{1}{|C_j^u|} \sum_{x_i \in C_j^u} F_\theta(x_i).$$

$$\hat{\mathcal{P}} = \arg \min_{\mathcal{P} \in \mathcal{P}_{all}} \sum_{i=1}^M \mathcal{L}_{match}(\mu_i^l, \mu_{\mathcal{P}(i)}^u) \quad (2)$$

$$\mathcal{L}_{match}(\mu_i^l, \mu_{\mathcal{P}(i)}^u) = \left\| \mu_i^l - \mu_{\mathcal{P}(i)}^u \right\|_2 \quad (3)$$

Approach

Unsupervised Learning for Novel Categories.

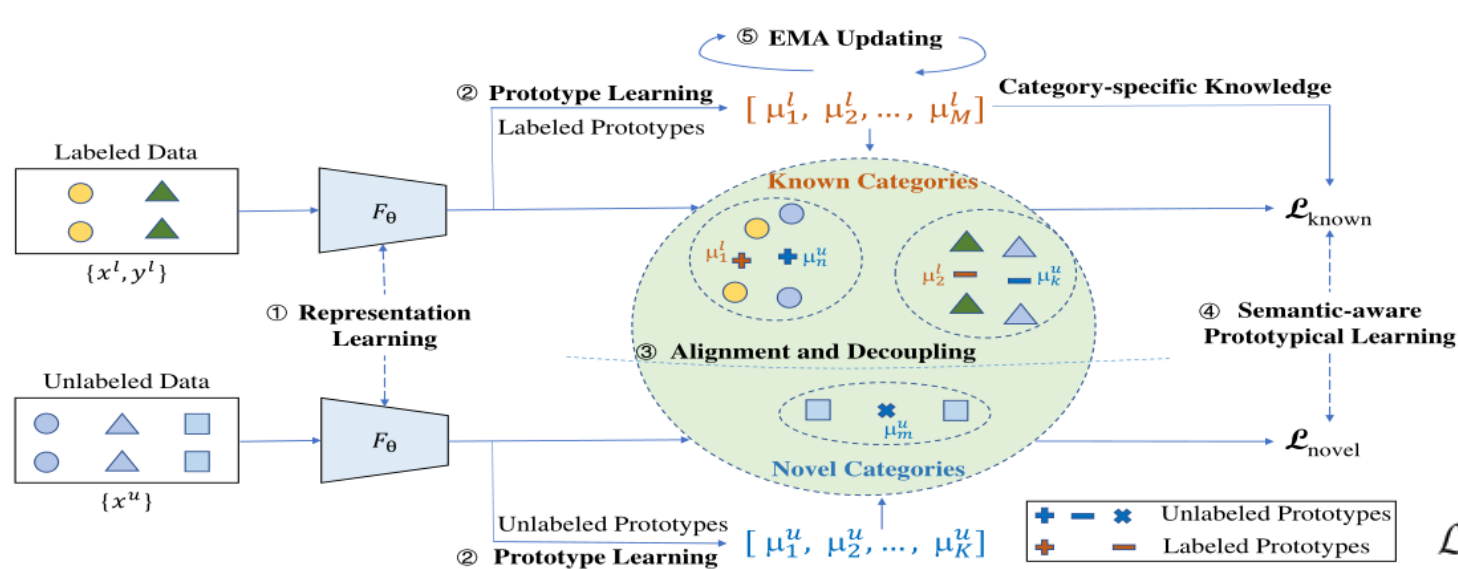


Figure 1: An overview of our model.

$$\mathcal{L}_{pl} = -\frac{1}{n} \sum_{i=1}^n \log \frac{e^{-d(F_{\theta}(x_i), \mu_g^u)}}{\sum_{j=1}^K e^{-d(F_{\theta}(x_i), \mu_j^u)}} \quad (4)$$

$$\mathcal{L}_{spl} = \frac{1}{n} \sum_{i=1}^n \sum_{k=1}^{K'} d(F_{\theta}(x_i), \mu_k^u) \frac{e^{s(F_{\theta}(x_i), \mu_k^u)}}{\sum_{j=1}^{K'} e^{s(F_{\theta}(x_i), \mu_j^u)}} \quad (5)$$

$$\mathcal{L}_{spl} = \frac{1}{n} \sum_{i=1}^n \sum_{k=1}^{K'} \|F_{\theta}(x_i) - \mu_k^u\|_2 \frac{e^{\cos(F_{\theta}(x_i), \mu_k^u)/\tau}}{\sum_{j=1}^{K'} e^{\cos(F_{\theta}(x_i), \mu_j^u)/\tau}} \quad (6)$$

$$\mathcal{L}_{novel} = \mathcal{L}_{spl}(\mathcal{D}^{un}, P^{un}) \quad (7)$$

Approach

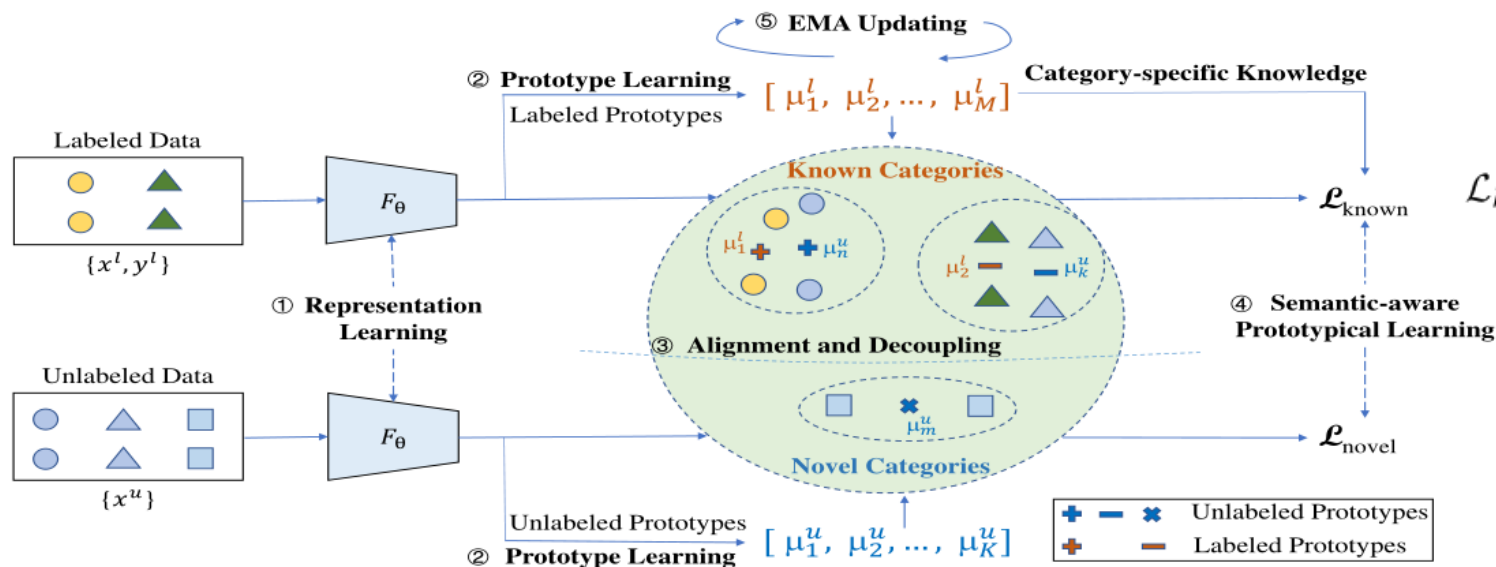


Figure 1: An overview of our model.

$$\mathcal{L}_{reg} = \frac{1}{r} \sum_{i=1}^r \sum_{k=1}^M (1 - \cos(F_\theta(x_i), \mu_k^l)) \frac{e^{\cos(F_\theta(x_i), \mu_k^l)/\tau}}{\sum_{j=1}^M e^{\cos(F_\theta(x_i), \mu_j^l)/\tau}} \quad (8)$$

$$\mathcal{L}_{known} = \mathcal{L}_{spl}(\mathcal{D}^{uk}, P^{uk}) + \mathcal{L}_{ce}(\mathcal{D}^l) + \gamma \cdot \mathcal{L}_{reg}(\mathcal{D}^{uk}, P^l) \quad (9)$$

$$\mathcal{L}_{dpn} = \mathcal{L}_{novel} + \mathcal{L}_{known} \quad (10)$$

$$\mathcal{P}_{t+1}^l \leftarrow \alpha \cdot \mathcal{P}_t^l + (1 - \alpha) \cdot \mathcal{P}_{t+1}^l \quad (11)$$



Experiments

Dataset	$ \mathcal{Y}_k $	$ \mathcal{Y}_n $	$ \mathcal{D}^l $	$ \mathcal{D}^u $	$ \mathcal{D}^t $
BANKING	58	19	673	8,330	3,080
StackOverflow	15	5	1,350	16,650	1,000
CLINC	113	37	1,344	16,656	2,250

Table 1: Statistics of datasets. $|\mathcal{Y}_k|$, $|\mathcal{Y}_n|$, $|\mathcal{D}^l|$, $|\mathcal{D}^u|$ and $|\mathcal{D}^t|$ represent the number of known categories, novel categories, labeled data, unlabeled data and testing data, respectively.



Experiments

Method	BANKING			StackOverflow			CLINC		
	All	Known	Novel	All	Known	Novel	All	Known	Novel
DeepCluster	13.95	13.94	13.99	17.37	18.22	14.80	26.92	27.34	25.67
DCN	17.85	18.94	14.35	29.10	28.94	29.51	29.64	30.00	28.45
DEC	19.30	20.36	15.84	19.30	20.36	15.84	19.99	20.18	19.40
BERT	21.29	21.48	20.70	16.80	16.67	17.20	34.52	34.98	33.16
KM-GloVe	29.18	29.11	29.39	28.40	28.60	28.05	51.64	51.74	51.50
AG-GloVe	30.09	29.69	31.29	29.23	28.49	31.56	44.70	45.17	43.20
SAE	38.05	38.29	37.27	60.33	57.36	69.02	46.59	47.35	44.24
Semi-DC	50.73	53.37	42.63	64.90	66.13	61.20	74.52	75.60	71.34
CDAC+	53.09	55.42	46.01	76.67	77.51	74.13	69.75	70.08	68.77
Self-Labeling	56.19	61.64	39.56	71.03	78.53	48.53	72.69	80.06	49.65
DTC	56.56	59.98	46.10	70.50	80.93	51.87	76.42	82.34	58.95
DAC	63.63	69.60	45.44	70.77	76.13	54.67	84.42	89.10	70.59
Semi-KM	66.23	73.62	43.68	73.13	81.02	49.47	81.42	89.03	59.01
LASKM	67.55	75.16	44.34	74.83	82.00	53.33	79.26	89.64	48.66
DPN (Ours)	72.96	80.93	48.60	84.23	85.29	81.07	89.06	92.97	77.54
Improvement	+5.41	+5.77	+2.50	+7.56	+3.29	+6.94	+4.64	+3.33	+6.20

Table 2: Model comparison results (%) on testing sets. Average results over 3 runs are reported.



Experiments

Model	All	Known	Novel
Ours	84.23	85.29	81.07
w/o Cross Entropy	83.83	85.02	80.26
w/o EMA	82.50	83.87	78.40
w/o Decoupling	78.77	78.53	79.47
w/o Soft Assignment	75.10	75.33	74.40
w/o Semantic Weights	35.70	33.73	41.60

Table 3: Results (%) of different model variants.

Experiments

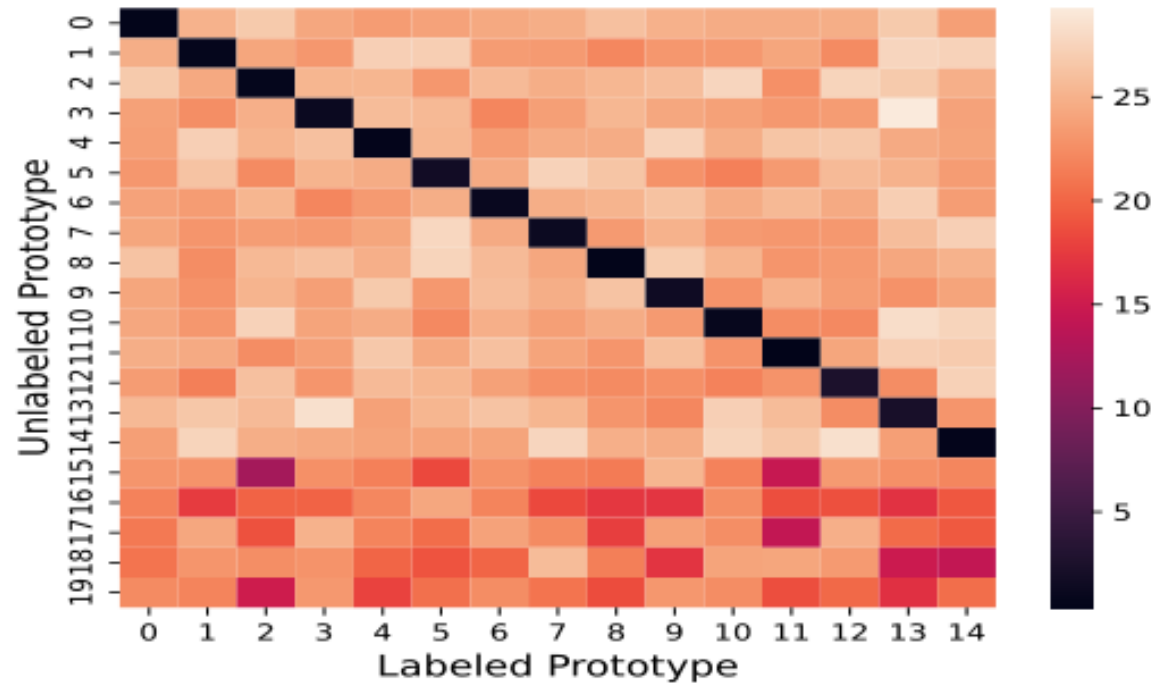


Figure 2: Distances between 15 labeled prototypes and 20 aligned unlabeled prototypes. Darker colors represent closer distances.

Experiments

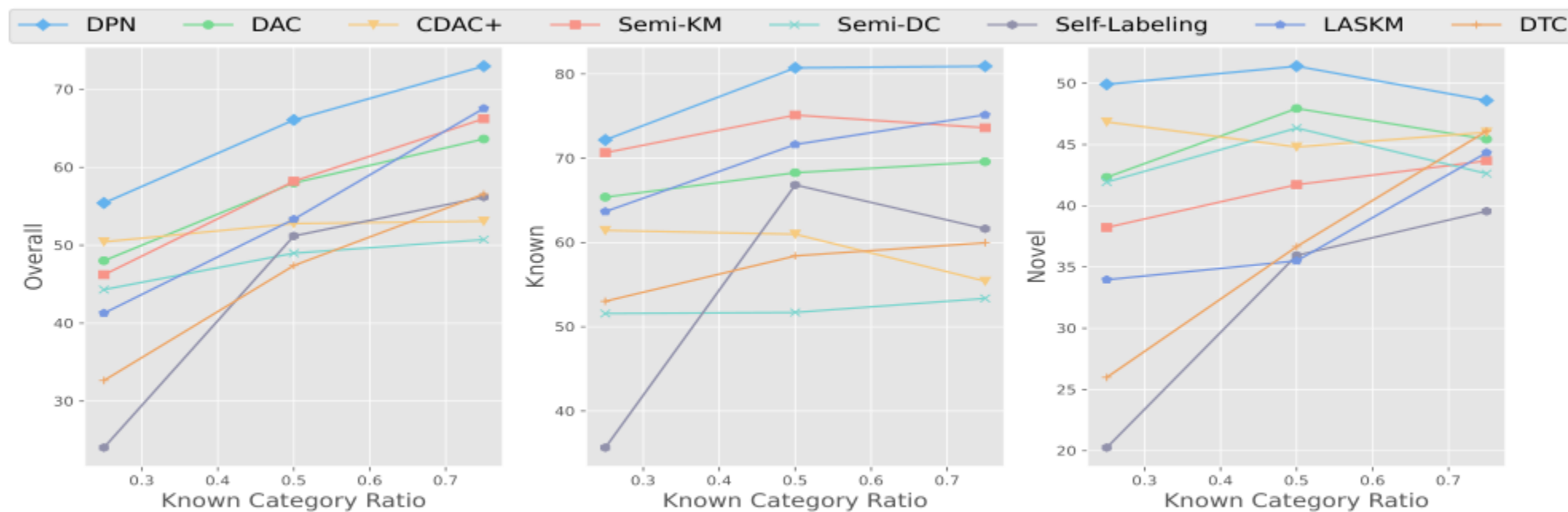


Figure 3: Effect of known category ratio on the BANKING dataset.

Experiments

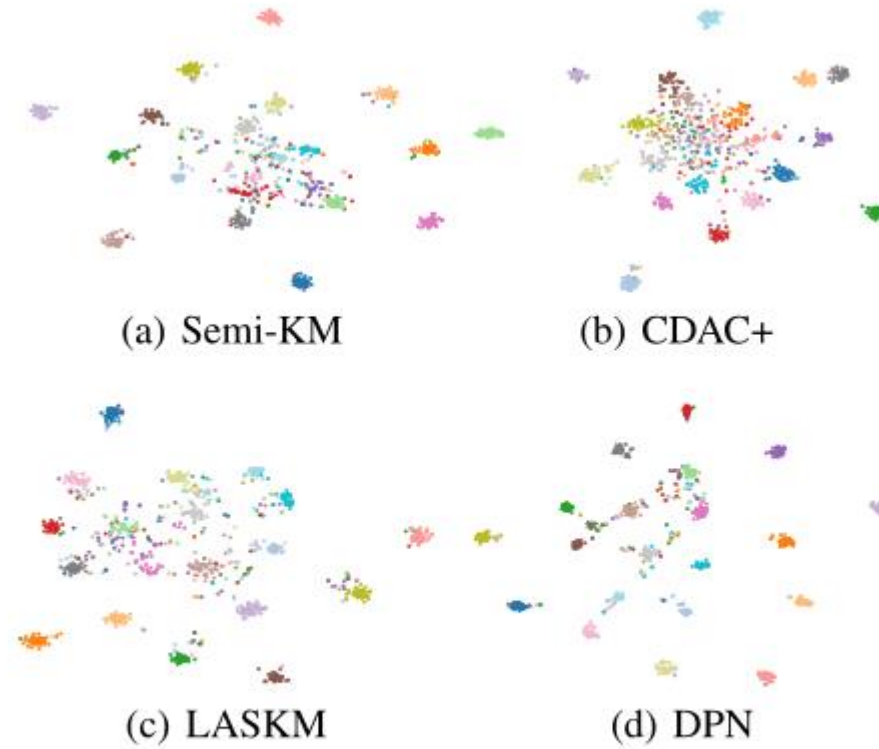


Figure 4: The t-SNE visualizations of embeddings.



Experiments

	CLINC	BANKING	StackOverflow
Ground Truth	150	77	20
DAC	130	66	15
Ours	137	67	18
Error	8.7%	13.0%	10.0%

Table 4: Estimation of the number of categories.



Thank you !