# Generalized Category Discovery with Decoupled Prototypical Network

Wenbin An[1,3], Feng Tian[2,3], Qinghua Zheng[2,3], Wei Ding[4], QianYing Wang[5], Ping Chen[6]
[1]School of Automation Science and Engineering, Xi'an Jiaotong University
[2]School of Computer Science and Technology, Xi'an Jiaotong University
[3]National Engineering Laboratory for Big Data Analytics
[4]Department of Computer Science, University of Massachusetts Boston
[5]Lenovo Research
[6]Department of Engineering, University of Massachusetts Boston
wenbinan@stu.xjtu.edu.cn, {fengtian,qhzheng}@mail.xjtu.edu.cn
{wei.ding,Ping.Chen}@umb.edu, wangqya@lenovo.com

Code: https://github.com/Lackel/DPN

—— AAAI 2023

2023.2.16 • ChongQing

Reported by Renhui Luo

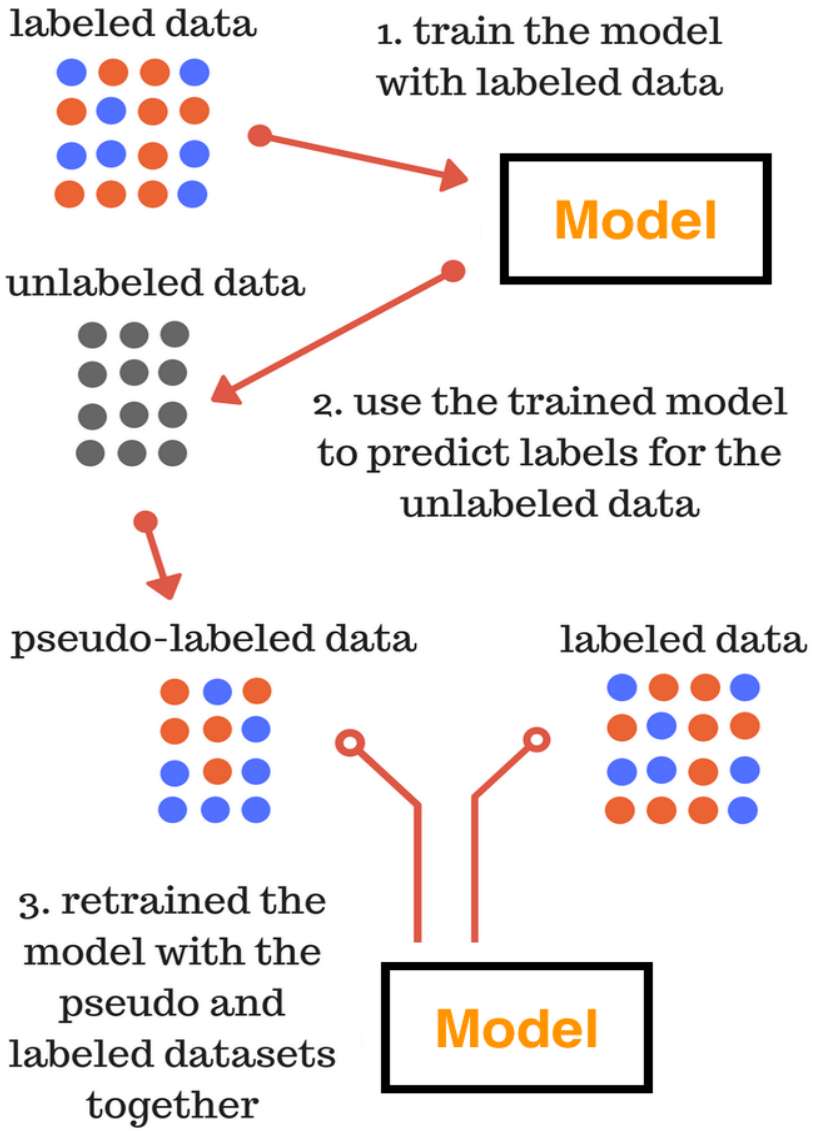
1.Introduction

2.Overview

3.Methods

4.Experiments

# Introduction



# Overview

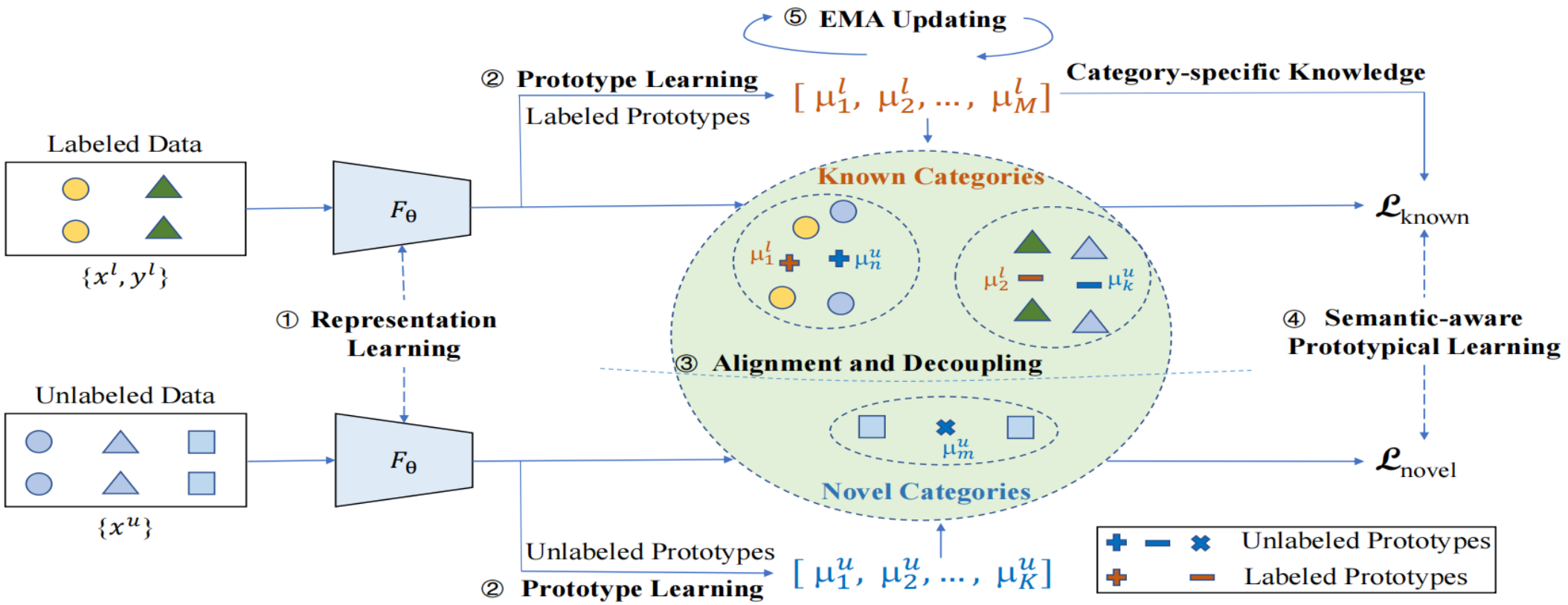
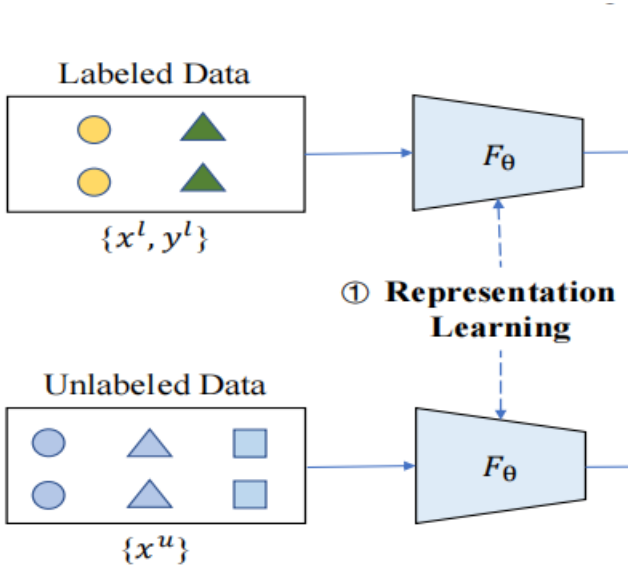


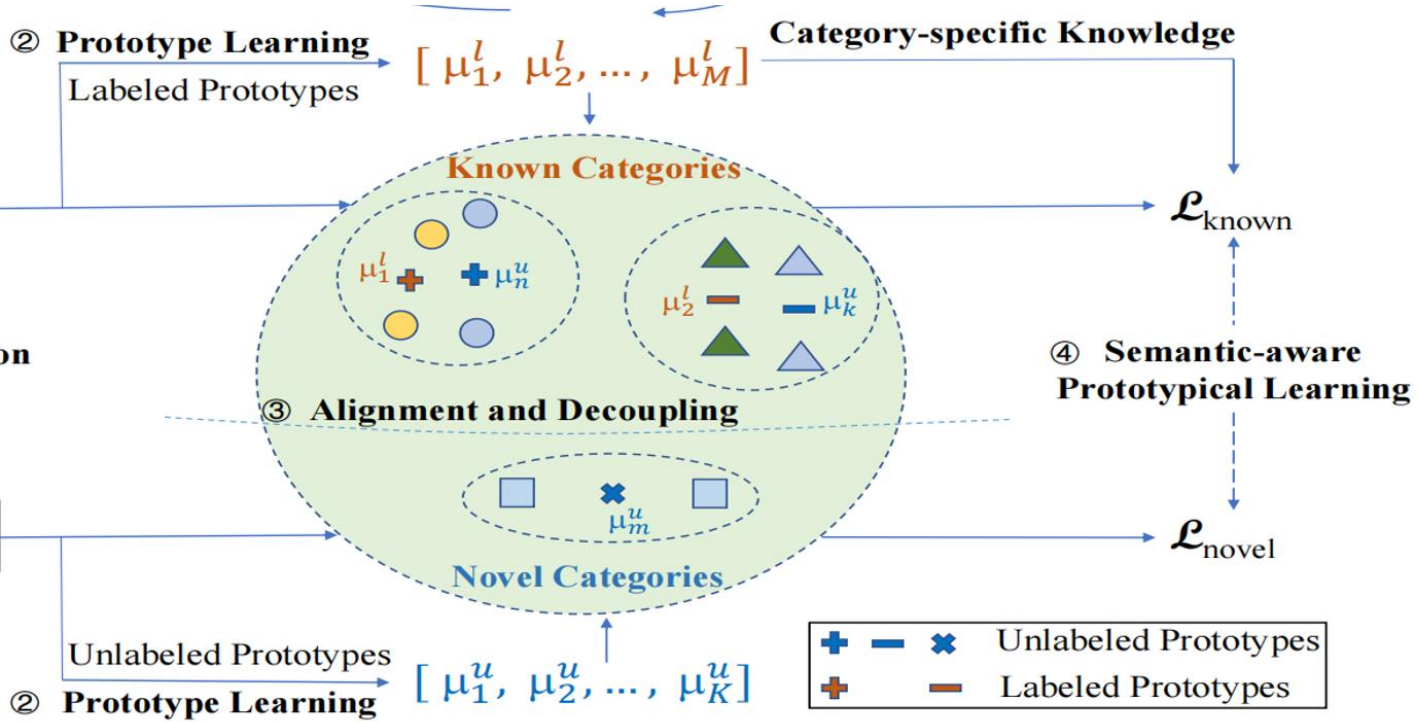

Figure 1: An overview of our model.

# Method




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

# Method




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

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

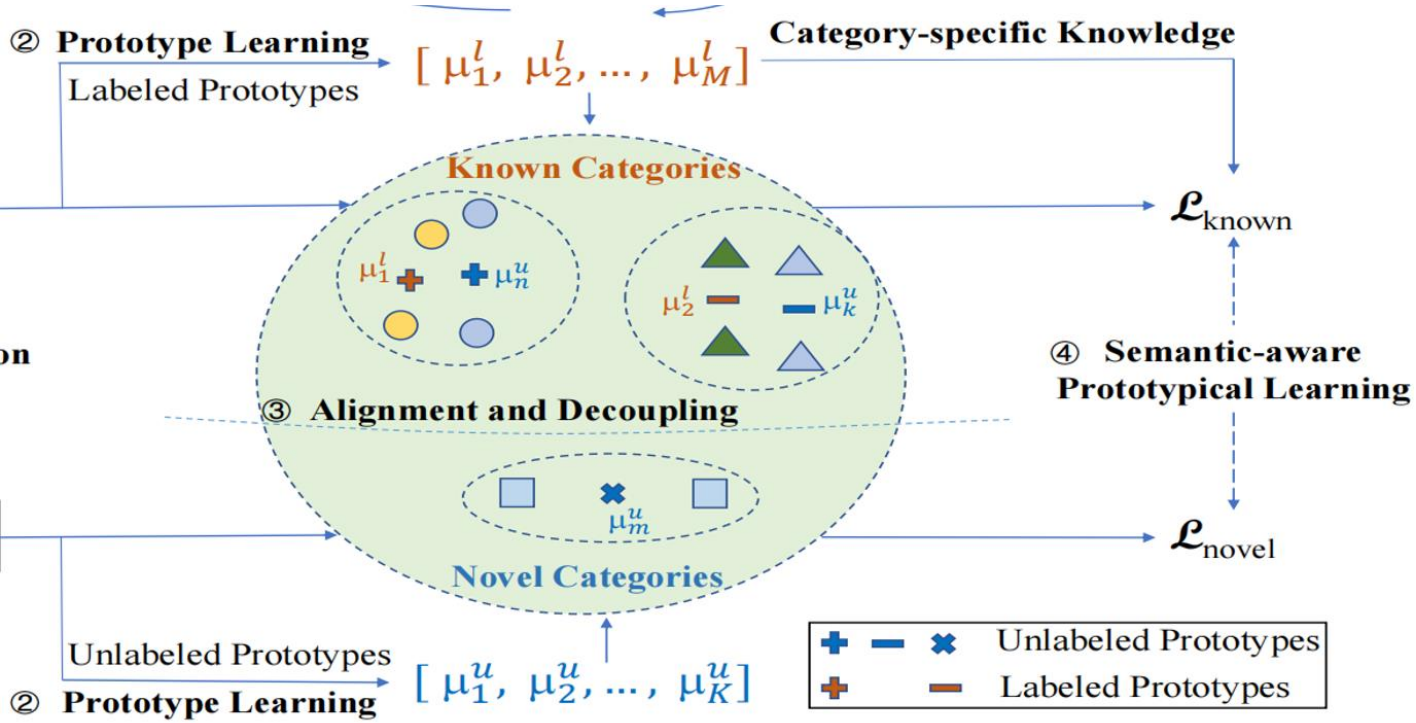
$$\mathcal{L}_{pl} = -\frac{1}{n}\sum_{i=1}^{n} log \frac{e^{-d(F_\theta(x_i), \mu_g^u)}}{\sum_{j=1}^{K} e^{-d(F_\theta(x_i), \mu_j^u)}} \tag{4}$$

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

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

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

# Method

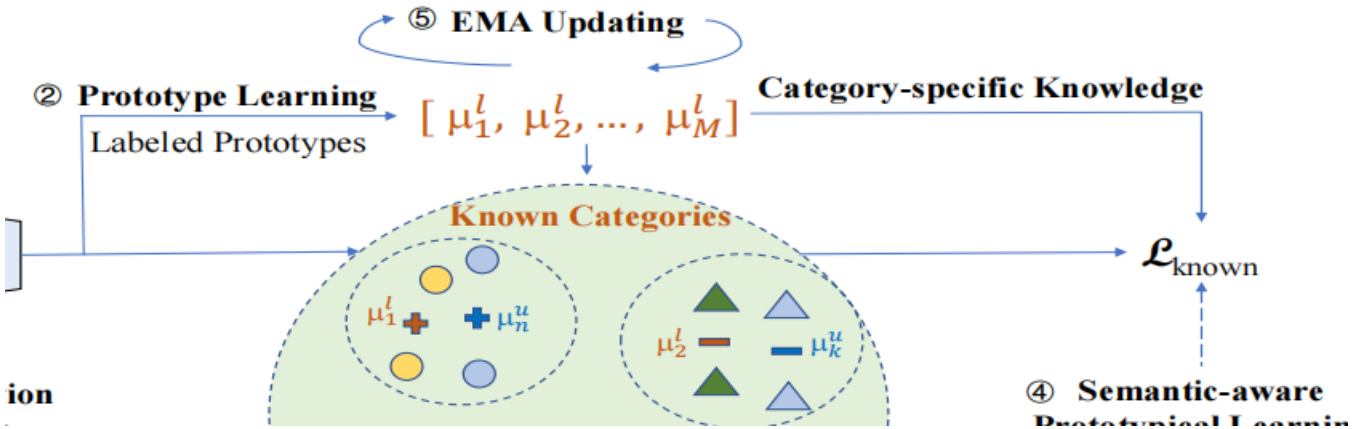



$$\mathcal{L}_{reg} = \frac{1}{r}\sum_{i=1}^{r}\sum_{k=1}^{M}(1-cos(F_\theta(x_i), \mu_k^l))\frac{e^{cos(F_\theta(x_i),\mu_k^l)/\tau}}{\sum_{j=1}^{M} e^{cos(F_\theta(x_i),\mu_j^l)/\tau}} \tag{8}$$

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

$$\mathcal{L}_{dpn} = \mathcal{L}_{novel} + \mathcal{L}_{known} \tag{10}$$

# Method




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

# Experiments

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.

| Dataset | $\lvert\mathcal{Y}_k\rvert$ | $\lvert\mathcal{Y}_n\rvert$ | $\lvert\mathcal{D}^l\rvert$ | $\lvert\mathcal{D}^u\rvert$ | $\lvert\mathcal{D}^t\rvert$ |
|---|---|---|---|---|---|
| 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 |

# Experiments

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

| 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)** | **73.61** | **80.04** | **53.99** | **83.20** | **84.18** | **80.27** | **87.62** | **91.29** | **76.79** |
| Improvement | +6.06 | +4.88 | +7.89 | +6.53 | +2.18 | +6.14 | +3.20 | +1.65 | +5.45 |

# Experiments

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

| **Model** | All | Known | Novel |
|---|---|---|---|
| Ours | 83.20 | 84.18 | 80.27 |
| w/o Cross Entropy | 82.53 | 83.47 | 79.73 |
| w/o EMA | 82.00 | 81.87 | 74.00 |
| w/o Decoupling | 81.10 | 82.93 | 75.60 |
| w/o Soft Assignment | 80.80 | 83.87 | 71.60 |
| w/o Semantic Weights | 70.50 | 72.53 | 64.40 |

# Experiments

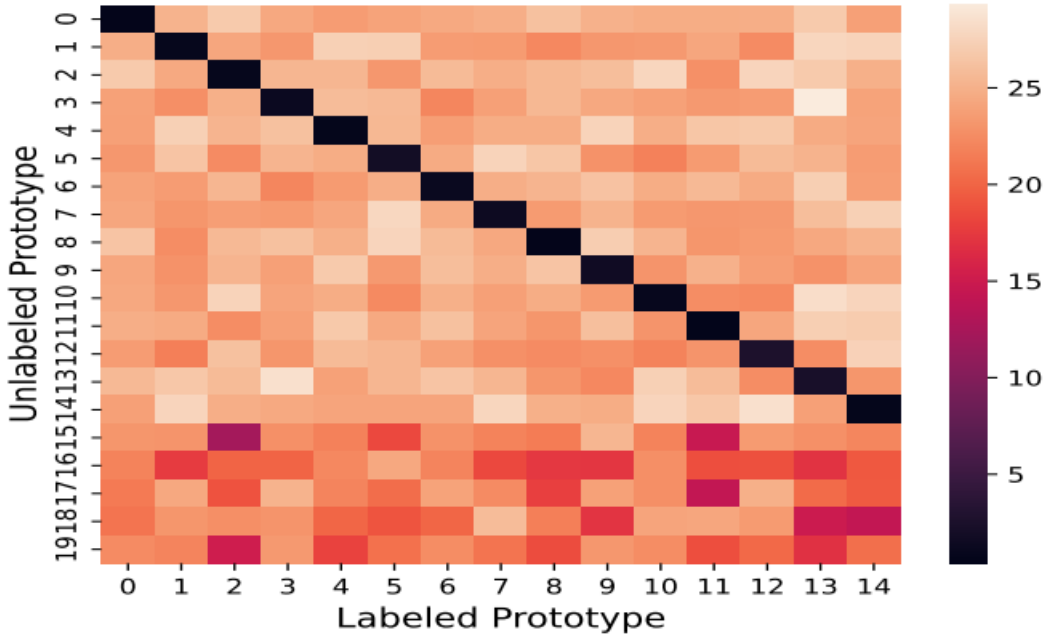



Figure 2: Distances between 15 labeled prototypes and 20 aligned unlabeled prototypes. Darker colors represent closer distances.

# Experiments

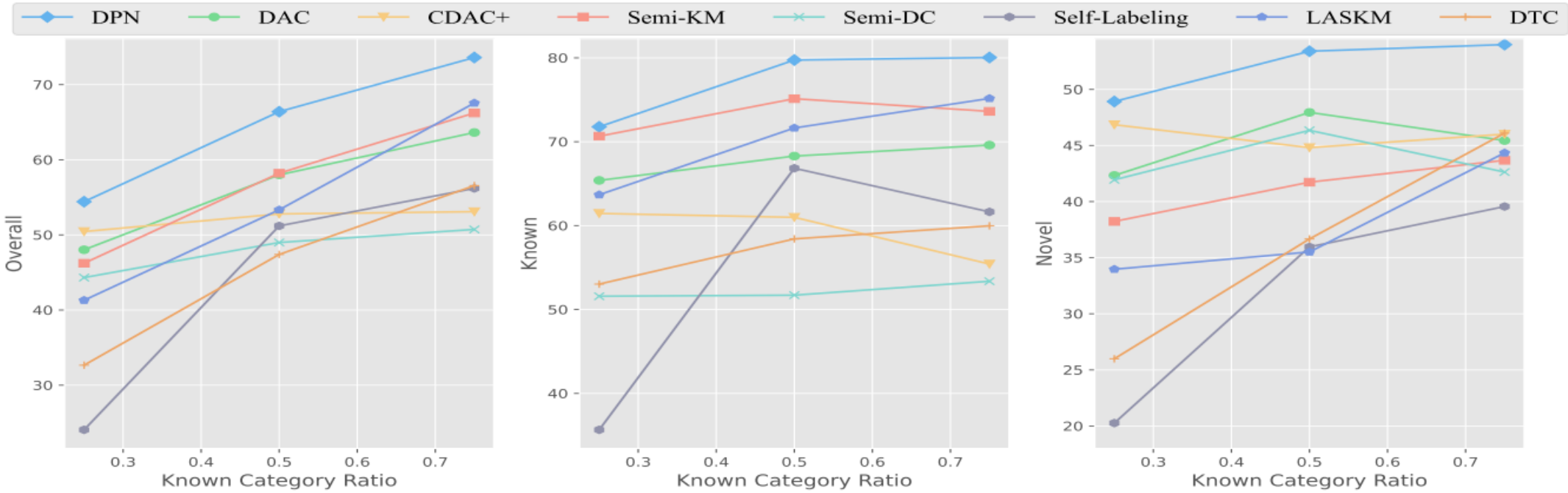



Figure 3: Effect of known category ratio on the BANKING dataset.

# Experiments

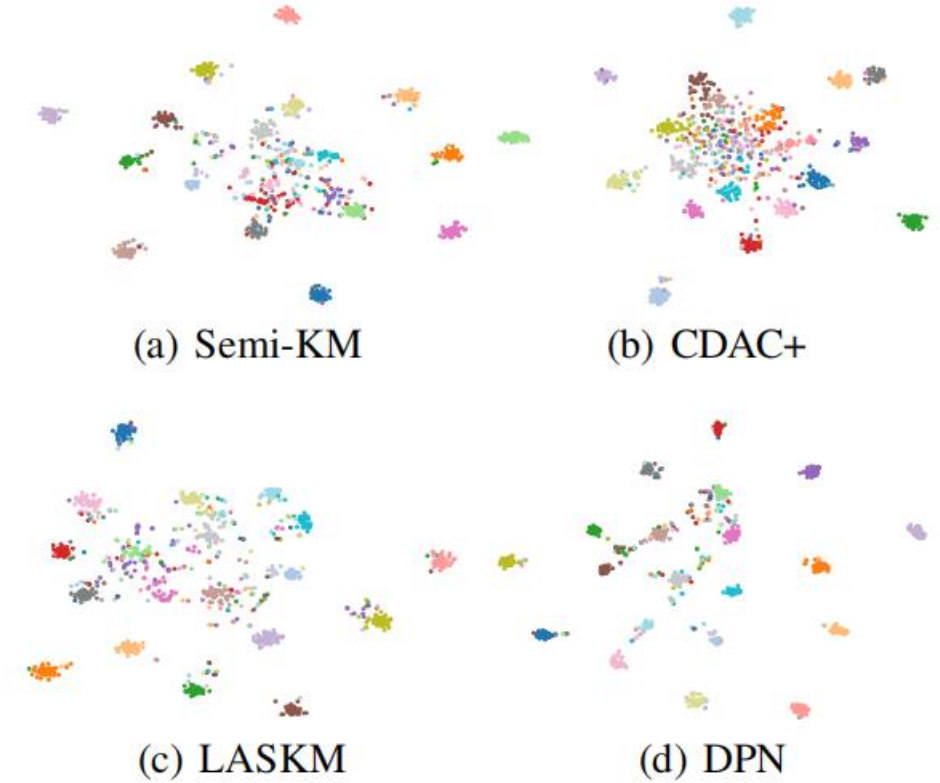



Figure 4: The t-SNE visualizations of embeddings.

# Experiments

Table 4: Estimation of the number of categories.

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

# Thanks!