HyperGCN: A New Method for Training Graph Convolutional Networks on Hypergraphs

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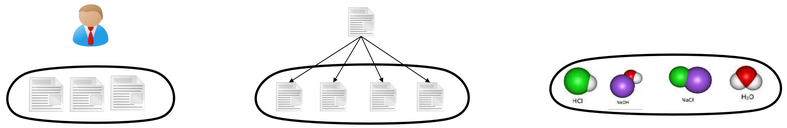
Motivation

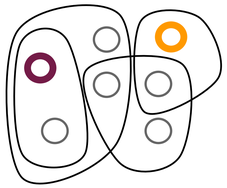
Networks have complex relationships



co-authorship | co-citation | chemical reaction

Modelled flexibly by hypergraphs

Hypergraph Semi-Supervised Learning



$\mathcal{H} = (V, E)$

Label vertices in U given labelled vertices in $V - U$

Challenges

- arbitrary size $E \subseteq 2^V$
- low supervision $|V - U| \ll |U|$
- noisy edges $|y_v : \ v \in e| > 1, \ e \in E$

- explicit regularisation **[Zhou et al., Hein et al.]**

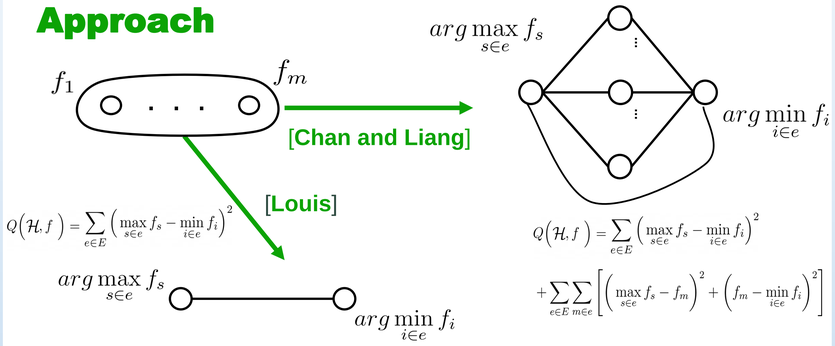
$$\mathcal{L} = \mathcal{L}_S + \lambda \cdot Q(\mathcal{H}, f)$$

✗ **hyperedges encode similarity**

- implicit regularisation **[Feng et al.]**

$f_{Neural}\left(\mathcal{H}, X\right) = ?$ $\quad \mathcal{L} = \mathcal{L}_S$ ✓ **need not encode similarity**

Approach



GCN [Kipf and Welling]

$$H^{\{l\}} = \sigma\left(A \cdot H^{\{l-1\}} \cdot W^{\{l\}}\right)$$

HyperGCN

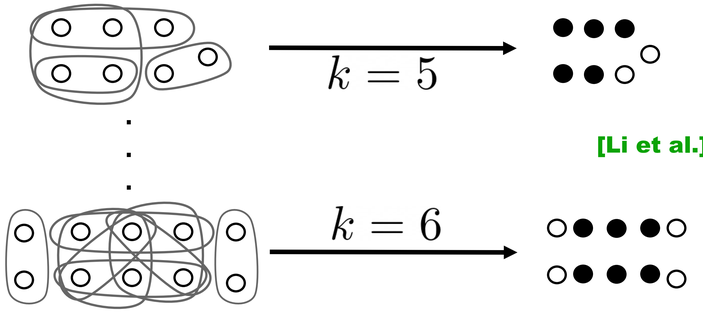
$$f = H^{\{l-1\}} \cdot W^{\{l\}}$$

FastHyperGCN

$$f = H^{\{0\}} = X$$

Densest k-subhypergraph

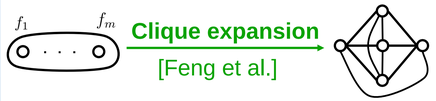
$$W \subseteq V, |W| = k, \ \text{maximise} \ |e \in E : \ e \subseteq W|$$



[Li et al.]

Results

Simple, strong baseline: HGNN



comparable on small hyperedges

Avg. size	3.0 ± 1.1	3.2 ± 2.0
Dataset	Cora	Citeseer
HGNN	32.41 ± 1.8	37.40 ± 1.6
HyperGCN	32.37 ± 1.7	37.35 ± 1.6
FastHyperGCN	32.42 ± 1.8	37.42 ± 1.7

test error (lower is better)

Avg. size	8.5 ± 8.8	4.3 ± 5.7
Dataset	DBLP	Pubmed
HGNN	45.27 ± 2.48	29.41 ± 1.5
HyperGCN	$\mathbf{41.64 \pm 2.6}$	$\mathbf{25.56 \pm 1.6}$
FastHyperGCN	41.79 ± 2.8	29.48 ± 1.6

training time (lower is better)

Dataset	DBLP	Pubmed
HGNN	0.115s	0.019s
FastHyperGCN	**0.035s**	**0.016s**

more accurate, faster on large noisy hyperedges

density for k = 0.75*|V| (higher is better) and training time (lower is better)

Dataset	DBLP	Pubmed	Cora	Citeseer
HGNN	6274	7865	437	**969**
HyperGCN	**7720**	**7928**	**504**	**971**
FastHyperGCN	7342	7893	452	**969**

Type	Training Time	Density
HGNN	170s	337
FastHyperGCN	**143s**	**352**

Moving forward

- unsupervised learning
- label correlation
- hypergraph pooling

code

Acknowledgement

Google

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