Uncertainty-aware Propagation Structure Reconstruction for Fake News Detection

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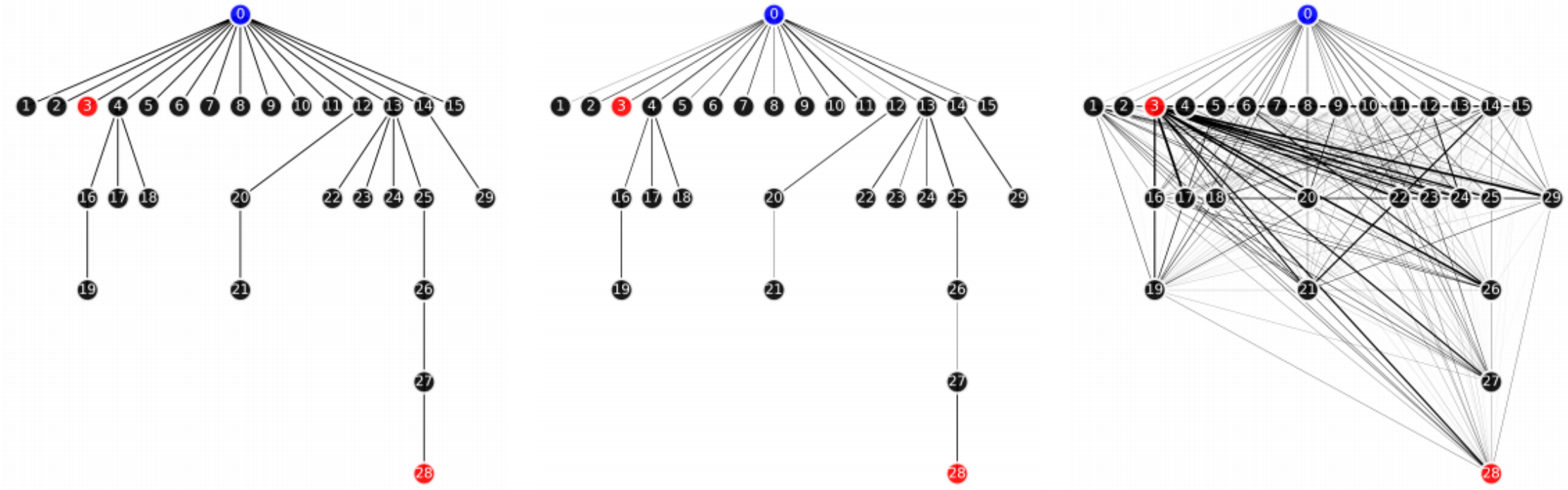
Introduction



(a) Original Propagation (b) Adjusted by EBGCN (c) Reconstructed by UPSR

Figure 3: A case study of fake news on *PolitiFact*, which is missed by BiGCN and EBGCN but detected by UPSR. Node 0 refers to the source news and other nodes are its retweets. The breadth of the propagation is 15 and the depth of the propagation is 5. The edge width represents the weight of interactions.

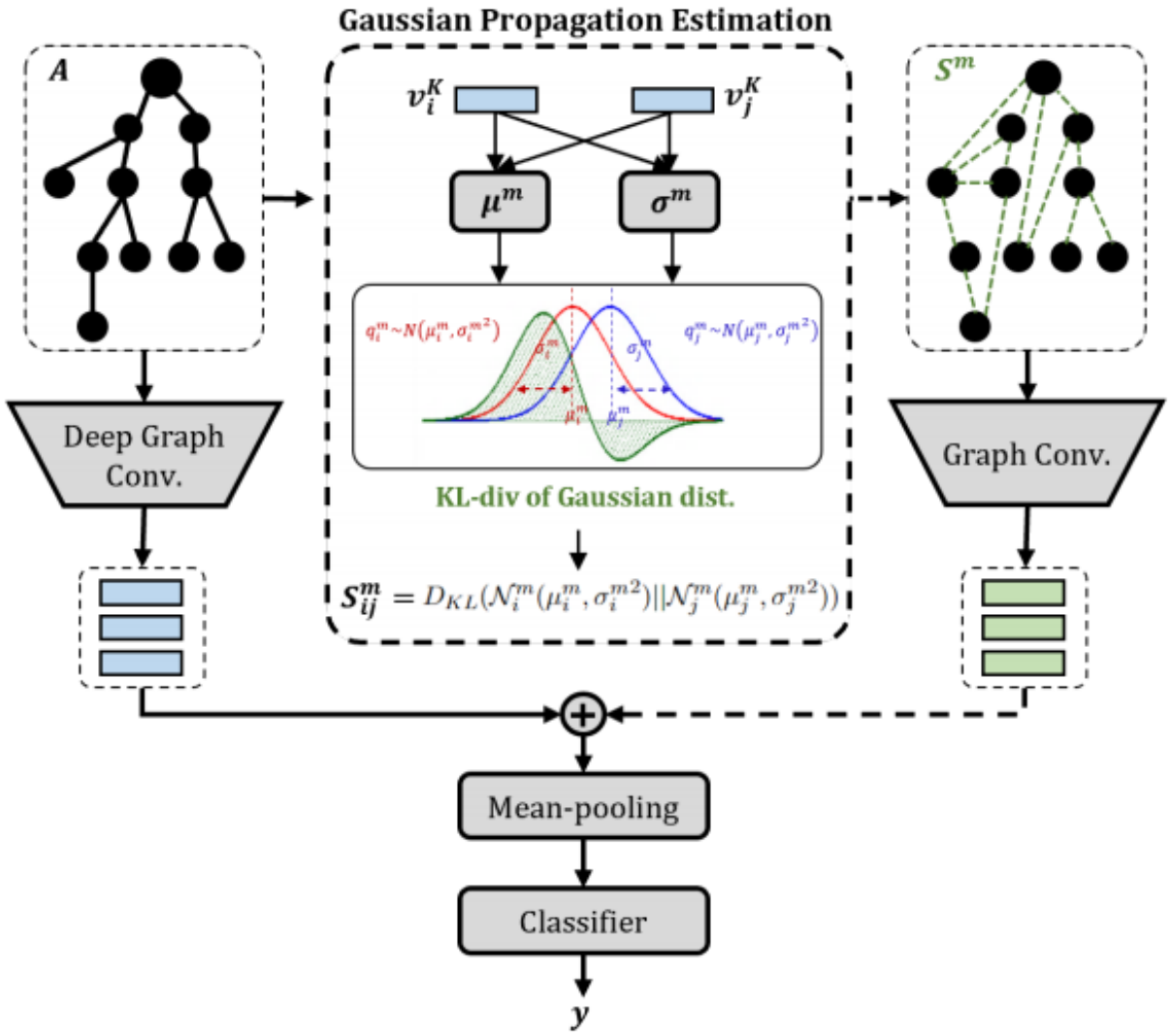


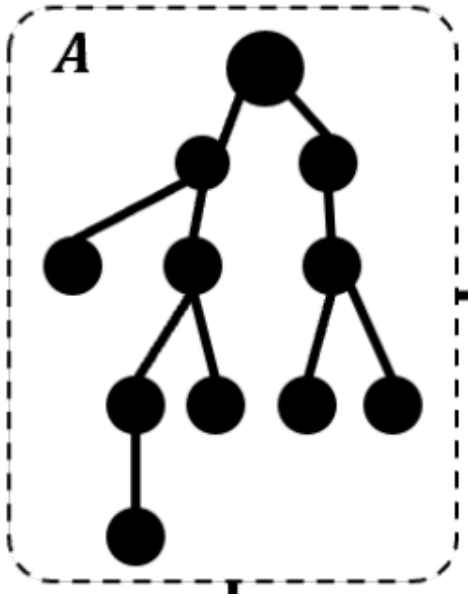
Figure 1: The overall architecture of UPSR.

Problem Statement

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

$$\mathcal{V} = \{r, c_1, ..., c_N\} \quad \mathbf{r} \in \mathbb{R}^{d_0}, \mathbf{c}_i \in \mathbb{R}^{d_0}$$

Graph Construction



$$\mathbf{V}^{(0)} = [\mathbf{r}, \mathbf{c}_1, ..., \mathbf{c}_N]$$

$$\mathbf{V}^{(k+1)} = \sigma\left(((1-\alpha_k)\tilde{\mathbf{P}}\mathbf{V}^{(k)} + \alpha_k\mathbf{V}^{(0)})((1-\beta_k)\mathbf{I}_n + \beta_k\mathbf{W}_t^{(k)})\right)$$

$$\tilde{\mathbf{P}} = (\mathbf{D}+\mathbf{I})^{-1/2}(\mathbf{A}+\mathbf{I})(\mathbf{D}+\mathbf{I})^{-1/2}$$

$$\mathbf{V}^{(K)} = \{\mathbf{v}_r^{(K)}, \mathbf{v}_1^{(K)}, ..., \mathbf{v}_N^{(K)}\}$$

Gaussian Propagation Estimation

$$\{\boldsymbol{\mu}_i^1, \boldsymbol{\mu}_i^2, ..., \boldsymbol{\mu}_i^M\} = g_\theta(\mathbf{v}_i^{(K)})$$
$$\{\boldsymbol{\sigma}_i^1, \boldsymbol{\sigma}_i^2, ..., \boldsymbol{\sigma}_i^M\} = \phi(g'_\theta(\mathbf{v}_i^{(K)})), \quad (2)$$

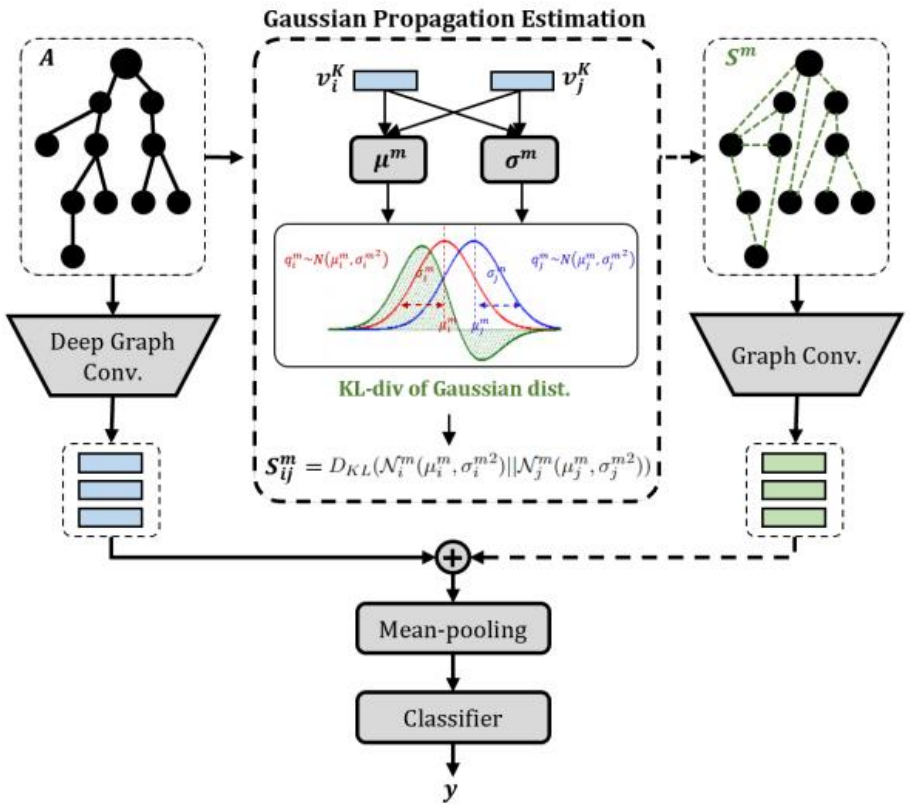
$$\mathbf{Q}^m = \{\mathbf{q}_r^m, \mathbf{q}_1^m, ..., \mathbf{q}_N^m\} \quad \mathcal{N}_i^m(\boldsymbol{\mu}_i^m, \boldsymbol{\sigma}_i^{m2})$$

$$\mathbf{q}_i^m = \boldsymbol{\mu}_i^m + \epsilon\boldsymbol{\sigma}_i^m, \epsilon \in \mathcal{N}(\mathbf{0}, \mathbf{I}). \quad (3)$$

$$\mathbf{S}_{ij}^m = D_{KL}(\mathcal{N}_i^m(\boldsymbol{\mu}_i^m, \boldsymbol{\sigma}_i^{m2}) || \mathcal{N}_j^m(\mu_j^m, \boldsymbol{\sigma}_j^{m2})). \quad (4)$$

$$\{\mathbf{Q}^1, \mathbf{Q}^2, ..., \mathbf{Q}^M\}$$

$$\{\mathbf{S}^1, \mathbf{S}^2, ..., \mathbf{S}^M\}$$



Method

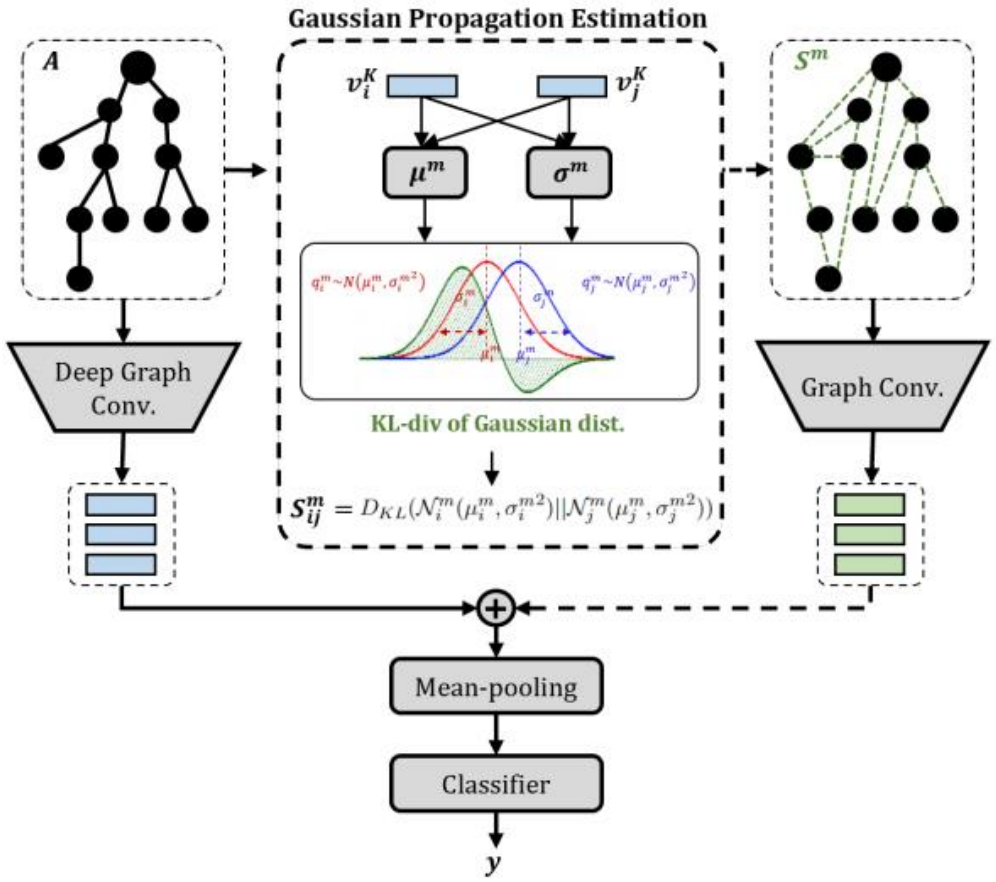
$$\mathbf{U}^m = \sigma\left(\hat{\mathbf{S}}^m(\sigma\left(\hat{\mathbf{S}}^m\mathbf{Q}^m\mathbf{W}_g^{(0)}\right))\mathbf{W}_g^{(1)}\right), \quad (5)$$

$$\mathbf{Z} = \mathbf{W}_z[\mathbf{U}^1; \mathbf{U}^2; ...; \mathbf{U}^M] + \mathbf{b}_z, \quad (6)$$

$$\mathbf{O} = meanpooling([\mathbf{V}; \mathbf{Z}]), \quad (7)$$

$$\hat{\mathbf{y}} = softmax\left(\mathbf{W}_o\mathbf{O} + \mathbf{b}_o\right), \quad (8)$$

$$\mathcal{L} = -\mathbf{y}\log(\hat{\mathbf{y}}) - (1-\mathbf{y})\log(1-\hat{\mathbf{y}}), \quad (9)$$



Experiments

Dataset	PolitiFact	GossipCop
# News	314	5,464
# True News	157	2,732
# Fake News	157	2,732
# Retweets	40,740	308,798
# Avg. Nodes per Graph	131	58
# Avg. Breadth per Graph	73.62	44.35
# Avg. Depth per Graph	3.75	2.51

Table 1: The statistics of two benchmark datasets.

Experiments

Method	PolitiFact				GossipCop			
	Acc	P	R	F1	Acc	P	R	F1
mGRU (Ma et al., 2016)	0.754	0.800	0.666	0.744	0.859	0.845	0.881	0.859
CSI (Ruchansky et al., 2017)	0.734	0.672	0.550	0.688	0.866	0.892	0.840	0.866
GAT (Velickovic et al., 2018)	0.861	0.848	0.883	0.853	0.958	0.957	0.959	0.957
GCNFN (Monti et al., 2019)	0.856	0.862	0.851	0.849	0.886	0.892	0.881	0.883
PLAN (Khoo et al., 2020)	0.868	0.861	0.879	0.858	0.962	0.960	0.945	0.953
BiGCN (Bian et al., 2020)	0.861	0.865	0.877	0.853	0.959	0.959	0.959	0.958
RumorGCN (Hu et al., 2021)	0.891	0.901	0.875	0.888	0.968	0.965	0.971	0.968
EBGCN (Wei et al., 2021)	0.896	0.898	0.909	0.891	0.964	0.966	0.962	0.963
UPSR	**0.914**	**0.911**	**0.917**	**0.910**	**0.977**	**0.980**	**0.974**	**0.976**

Table 2: Model performance for fake news detection on *PolitiFact* and *GossipCop*. The best result is in bold-face.

Experiments

Methods	PolitiFact		GossipCop	
	Acc	F1	Acc	F1
UPSR	**0.914**	**0.910**	**0.977**	**0.976**
- w/o Root	0.891	0.886	0.974	0.973
- w/o GPE	0.904	0.894	0.972	0.961
- w/o OPM	0.828	0.817	0.975	0.974
- w/o RPM	0.873	0.867	0.962	0.961
UPSR$_{\text{GCN}}$	0.891	0.886	0.972	0.971
UPSR$_{\text{GAT}}$	0.899	0.894	0.973	0.973
UPSR$_{\text{BiGCN}}$	0.886	0.880	0.974	0.973

Table 3: Results of ablation study and component analysis. The best result is in bold-face.

Experiments

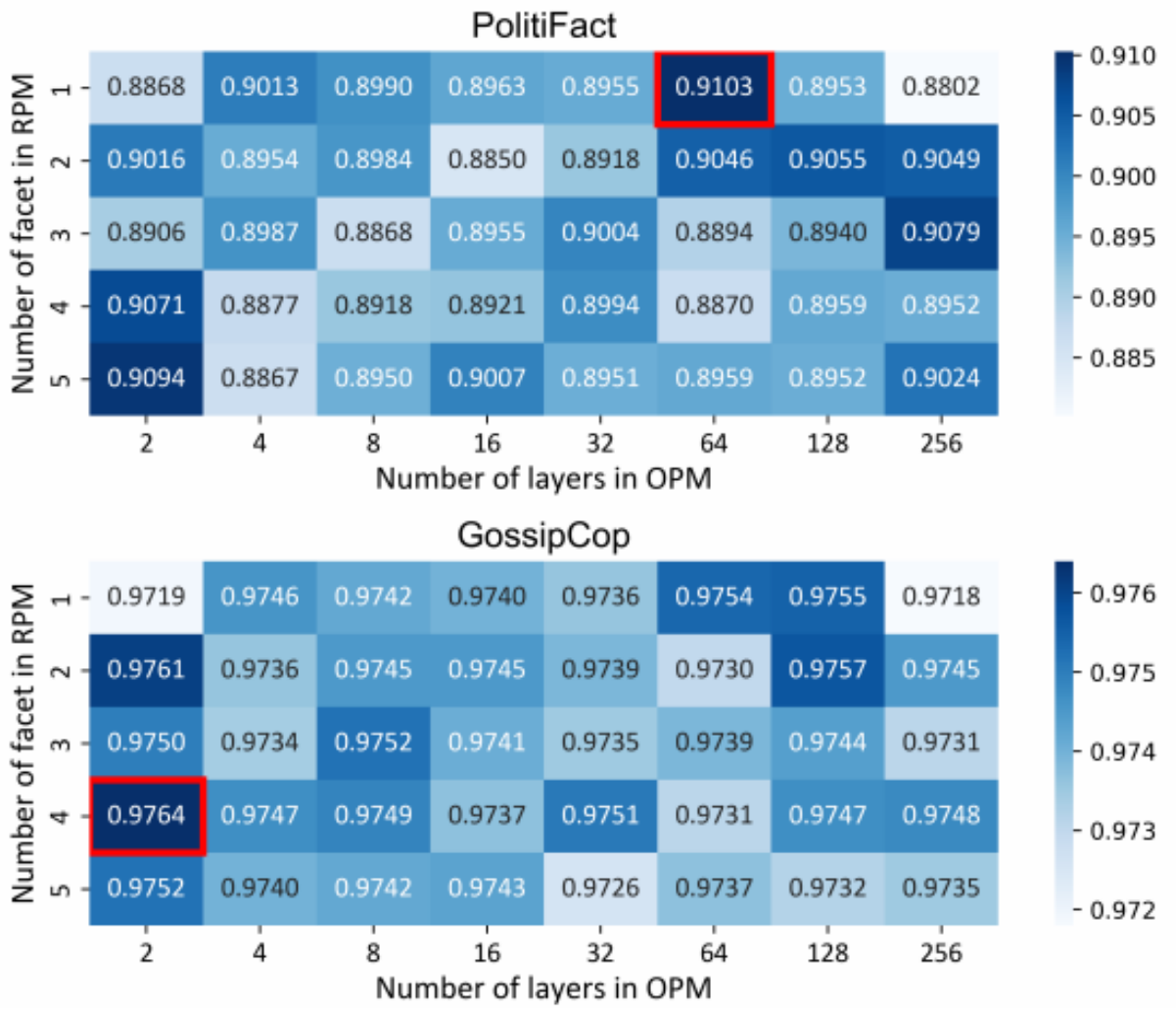


Figure 2: F1 scores against different hyperparameters.

Experiments

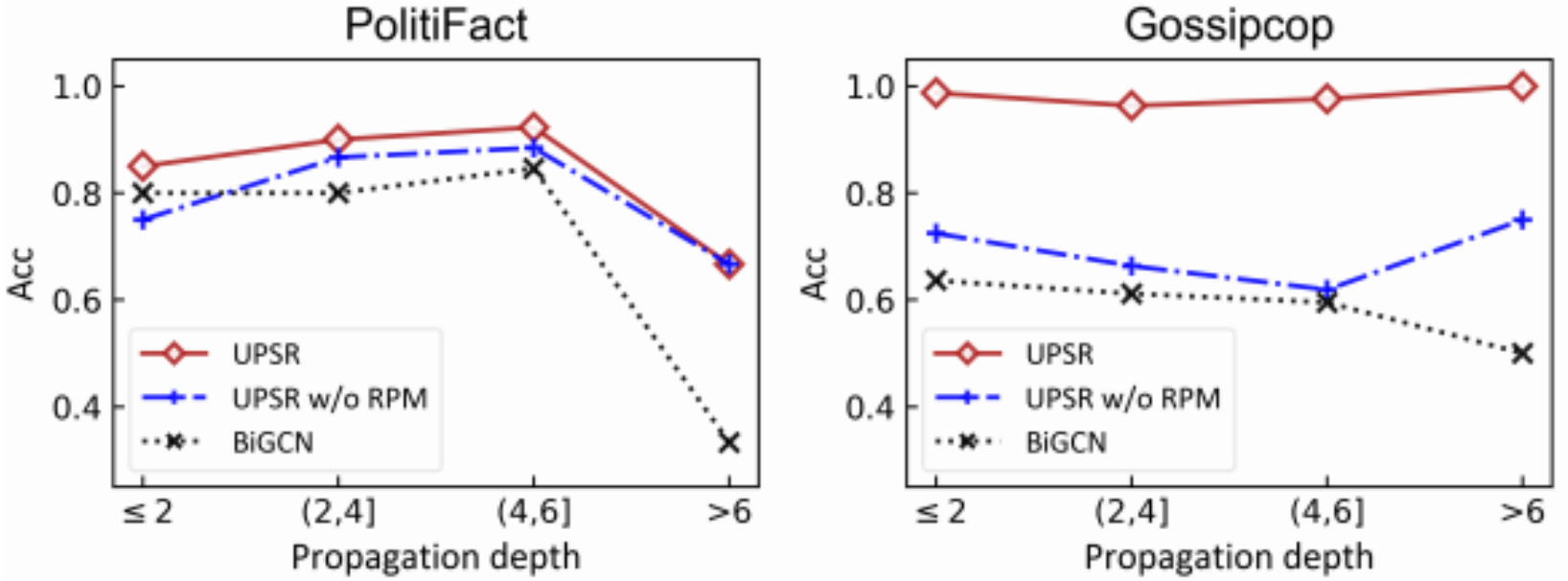


Figure 4: Performance on propagation structures with different depths. Y-axis refers to the accuracy score.

Thanks