

## Relational and Iterative Classification

## Topics

Relational classifiers

Iterative classification

Loopy belief propagation

Task

Predict label of unlabeled nodes

### Probabilistic Relational Classifier

```
def Update all nodes in a random order until convergence or until maximum
number of iterations is reached.
```

- involve
  - network structure
  - labels

$$P(Y_v = c) = \frac{1}{\sum_{(v,u) \in E} A_{v,u}} \sum_{(v,u) \in E} A_{v,u} P(Y_u = c)$$

a node prob of being class  $c$  = average of prob of neighbour being class  $c$

assumption      two nodes share the same label if connected

normalised	ensure $[0, 1]$
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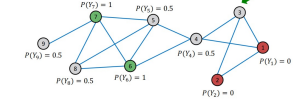
cannot use node feature information

Challenges

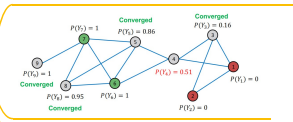
- Convergence is not guaranteed if value stay unchanged after update

- Update for the 1<sup>st</sup> iteration:

- For node 3,  $N_3 = \{1, 2, 4\}$

$$P(Y_2) = (0 + 0 + 0.5)/3 = 0.17$$


example



fix given labelled one, right to left assign prob to unlabelled one

## Iterative Classification

```
def Classify node v based on its attributes  $f_v$  as well as labels  $z_v$  of neighbor set  $N_v$ .
```

network structure

involve labels  
node

1 - base classifier $\phi_1$	Predict node label based on	node feature
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2 - relational classifier  $\phi_2$  Predict node label based on   
 node feature   
 summary of neighbours

- Phase 1: Classify based on node attributes alone

- On the labeled **training set**, train two classifiers:

- **Base classifier:**  $\phi_1(f_v)$  to predict  $Y_v$  based on  $f_v$
- **Relational classifier:**  $\phi_2(f_v, z_v)$  to predict  $Y_v$  based on  $f_v$  and summary  $z_v$  of labels of  $v$ 's neighbors

- Phase 2: Iterate till convergence

- On **test set**, set labels  $Y_v$  based on the classifier  $\phi_1$ , compute  $z_v$  and **predict the labels with  $\phi_2$**

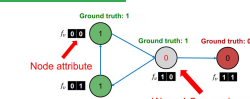
- **Repeat** for each node  $v$ :
  - Update  $z_v$  based on  $Y_u$  for all  $u \in N_v$
  - Update  $Y_v$  based on the new  $z_v$  ( $\phi_2$ )

- Iterate until class labels stabilize or max iterations is reached

- **Note:** Convergence is not guaranteed

neighbours

summary of neighbours

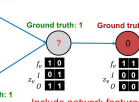


Wrong! Can we improve?

## binary features

how to predict the label with the node attributes

Ground truth: 1



Include network features

## 1. Train classifiers

2. Apply classifier to unlab. set

### 3. Iterate

4. Update relational features  $z_v$
5. Update label  $Y_v$

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