

Paper Implementation

# GCN: SEMI-SUPERVISED CLASSIFICATION WITH GRAPH CONVOLUTIONAL NETWORKS

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How to define  
spectral graph  
convolution?

# Main Idea

- Define layer-wise propagation rule for neural network models which operate directly on graphs.
- Use this form of of a graph-based neural network model for semi-supervised classification of nodes in a graph.

# Graph Convolution Update Rule

$$H' = \sigma(\tilde{D}^{-\frac{1}{2}} \tilde{A} \tilde{D}^{-\frac{1}{2}} H W)$$

$$\tilde{A} = A + I$$

$$\tilde{D}_{ii} = \sum_j \tilde{A}_{ij}$$

- Node-wise, this can be written as:

$$\vec{h}_i = \sigma\left(\sum_{j \in N_i} \frac{1}{\sqrt{|N_i||N_j|}} W \vec{h}_j\right)$$

- Simple and Powerful: most commonly cited GNN paper!

# Implementation approach

GCN paper

- Define one GCN layer:  
layer-wise propagation rule.
  - Stack two GCN layers, use relu  
and dropout between them.
  - Build the train function:  
(optimizer, loss...)
  - Experiments
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# The Experiments

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# Results

<b>Dataset</b>	<b>Type</b>	<b>Nodes</b>	<b>Edges</b>	<b>Classes</b>	<b>Features</b>	<b>Test Accuracy</b>
Cora	Citation network	2,708	5,429	7	1,433	$81.5 \pm 1$
Citeseer	Citation network	3,327	4,732	6	3,703	$69 \pm 0.8$

# Comparison

Dataset	Our experiment	Paper's result
Cora	$81.5 \pm 1$	81.5
Citeseer	$69 \pm 0.8$	70.3



# Improvement

A lot of architectures!

- MPNN (Gilmer et al., ICML 2017)
  - GAT (Velickovic et al., ICLR 2018)
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# MPNN (Gilmer et al., ICML 2017)

- Let  $\vec{m}_{ij}$  be the message sent from node  $i$  to node  $j$

- Compute  $\vec{m}_{ij}$  using a message function:

$$\vec{m}_{ij} = f_e(\vec{h}_i, \vec{h}_j, \vec{e}_{ij})$$

- Aggregate all the messages entering a node:

$$\vec{h}'_i = f_v(\vec{h}_i, \sum_{j \in N_i} \vec{m}_{ji})$$

# GAT (Velickovic et al., ICLR 2018)

- Let's consider the more general form of GCN:

$$\vec{h}'_i = \sigma(\sum_{j \in N_i} \alpha_{ij} W \vec{h}_j)$$

$$\alpha_{ij} = a(\vec{h}_i, \vec{h}_j, \vec{e}_{ij})$$

$$\alpha_{ij} = \frac{\exp(\alpha_{ij})}{\sum_{k \in N_i} \exp(\alpha_{ik})}$$

- $a$  is learnable!

# Conclusion

- GCN: how to define spectral graph convolution.
- Simple and powerful, most commonly cited GNN paper.
- A lot of architectures came as improvement of GCN.

Thank you!

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