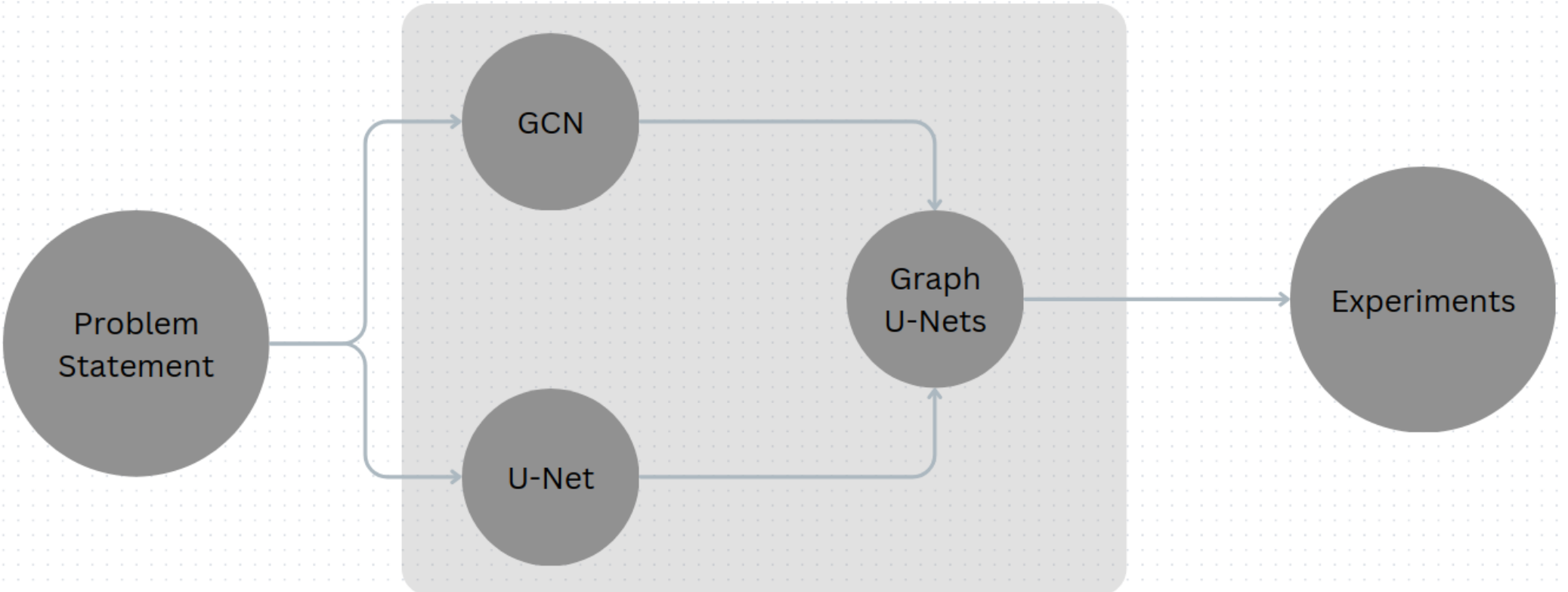
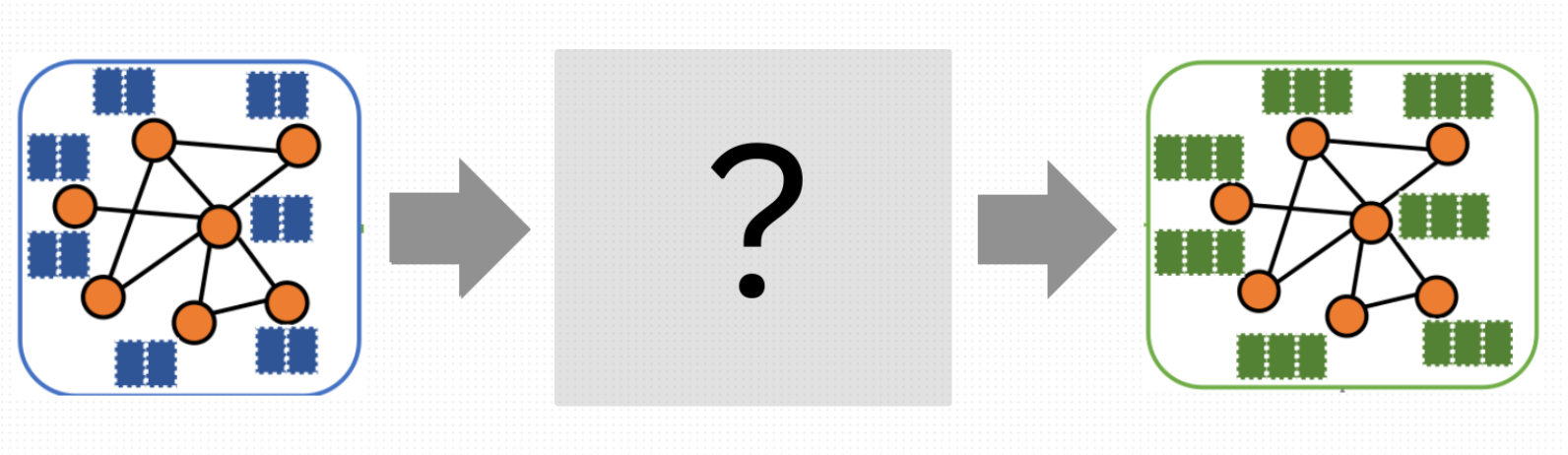
Graph U-Nets



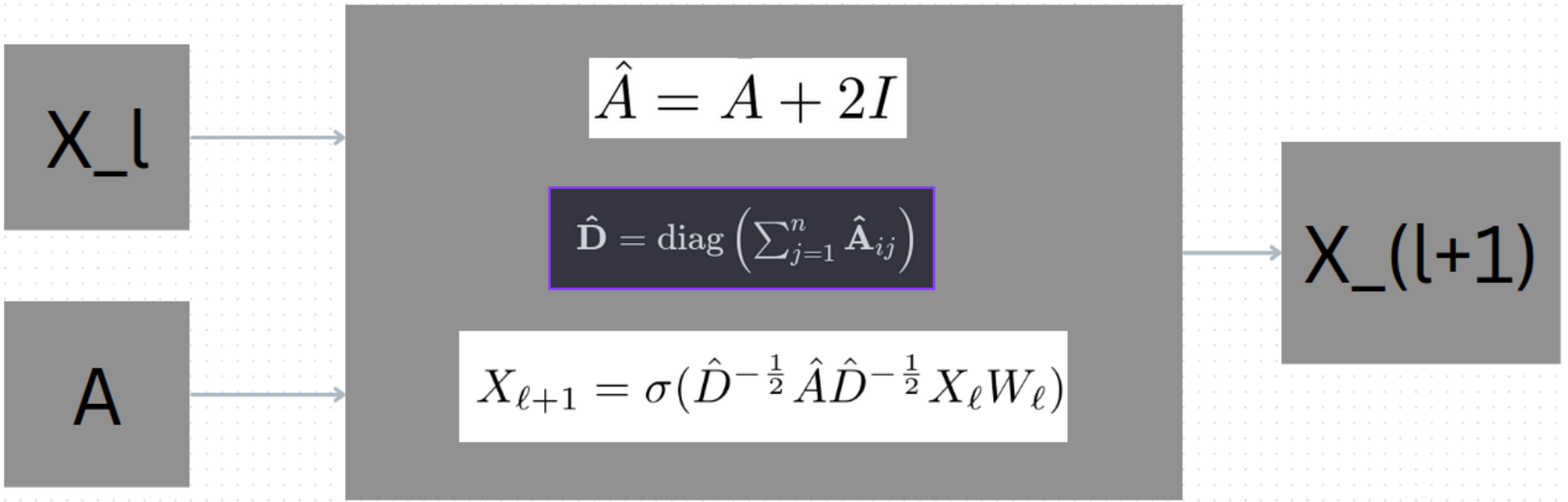
Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

Problem statement



Learn node embeddings

GCN



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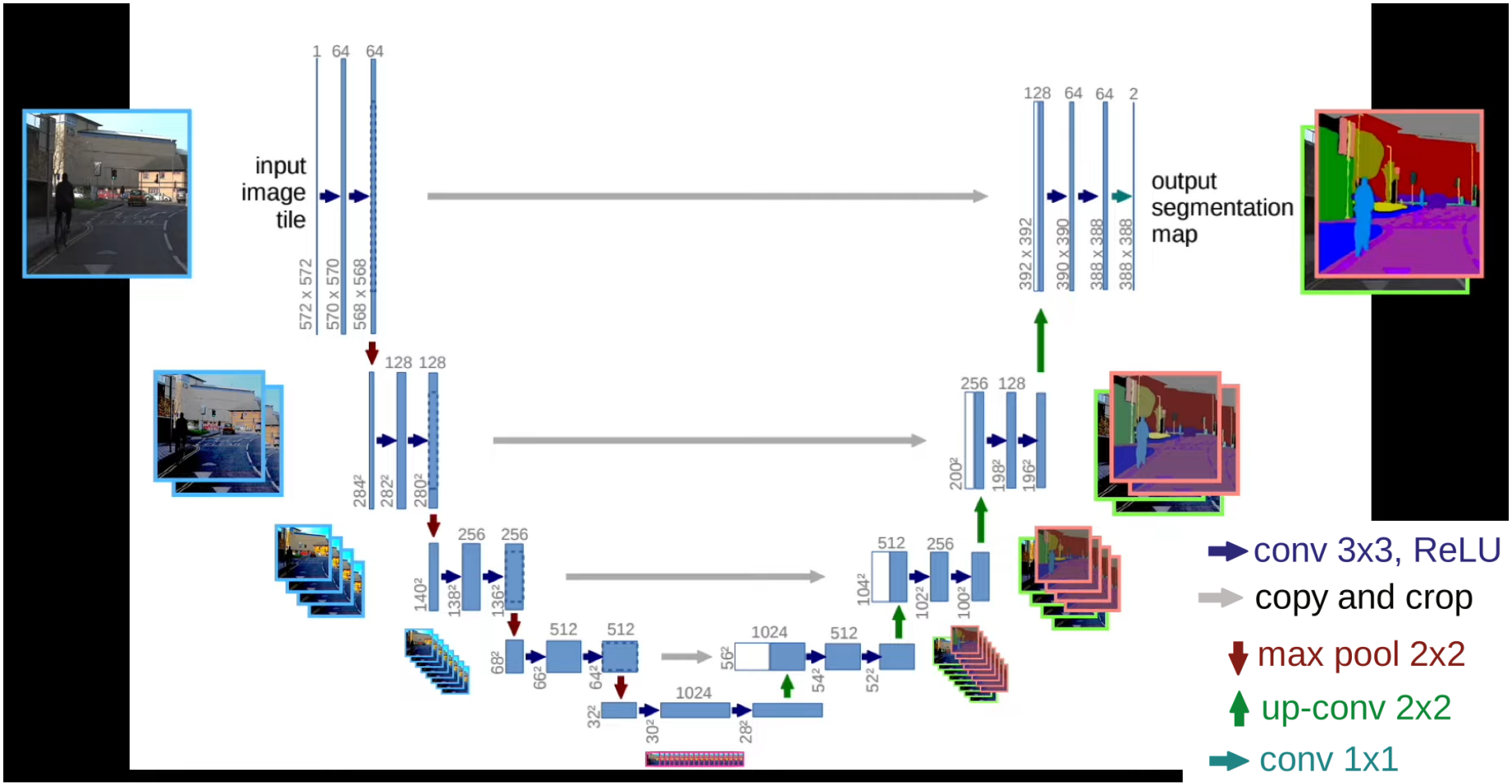
U-Net



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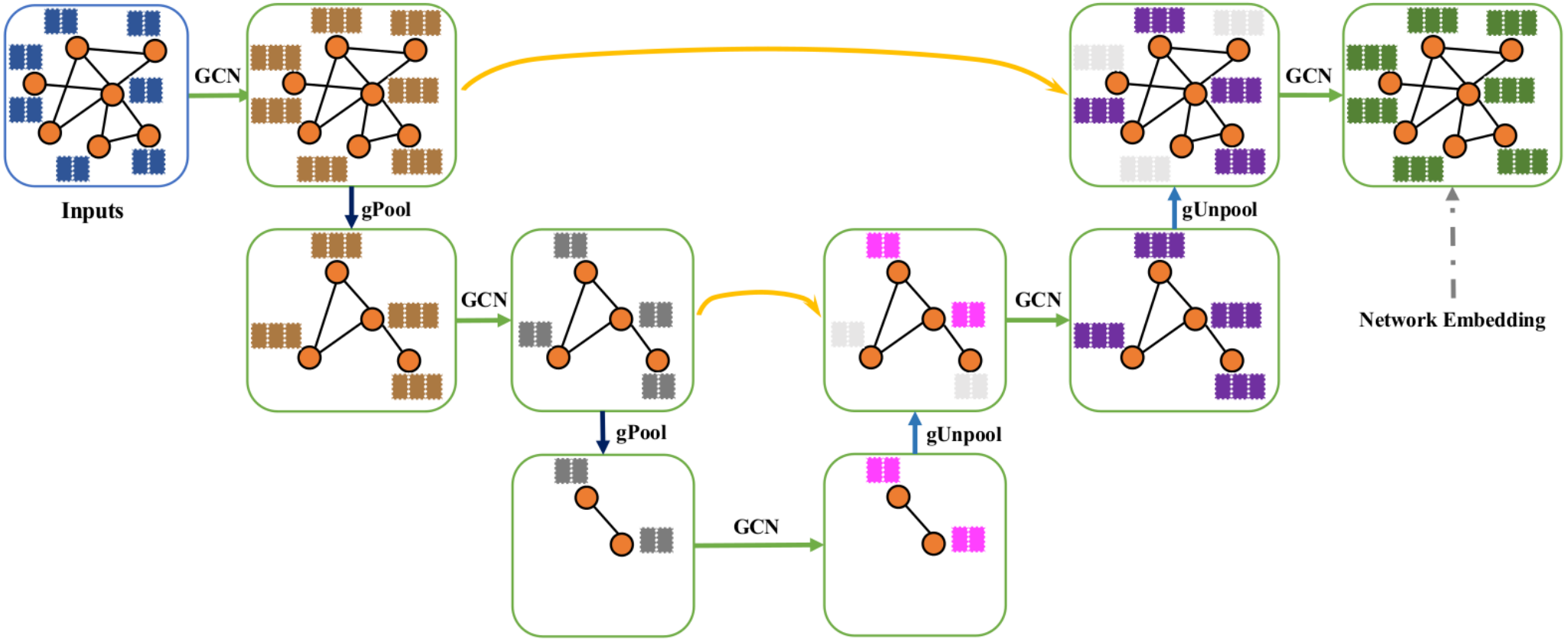
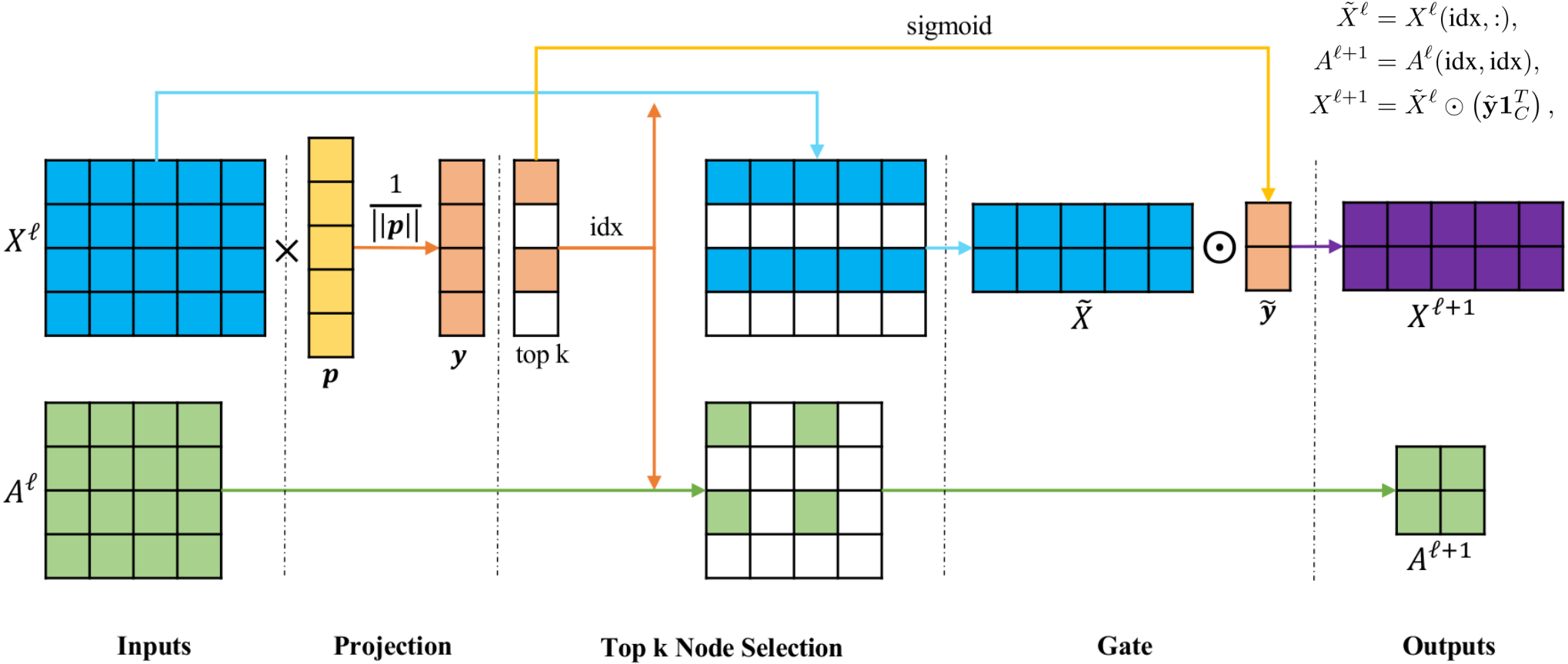
Graph U-Nets



Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

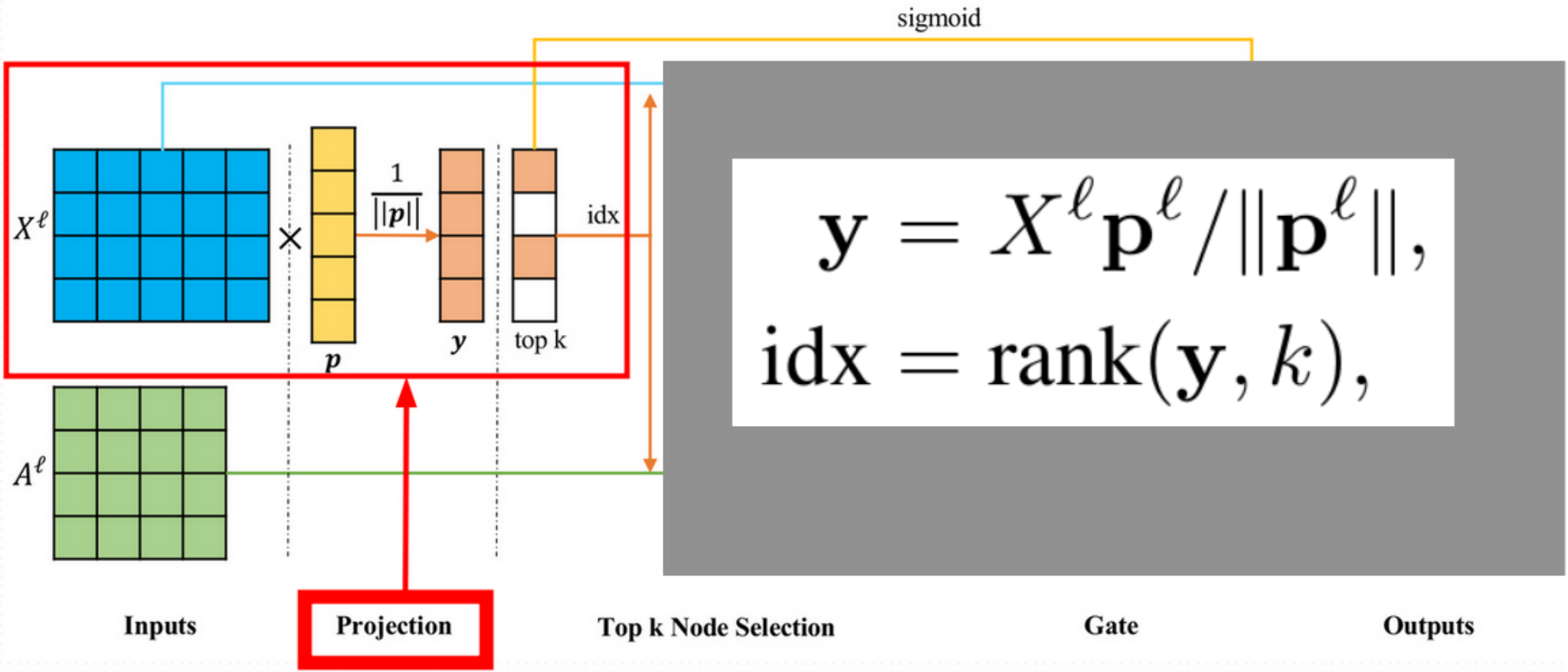
gPool

$$
\begin{aligned}
\mathbf{y} &= X^{\ell}\mathbf{p}^{\ell}/\|\mathbf{p}^{\ell}\|, \\
\text{idx} &= \text{rank}(\mathbf{y}, k), \\
\tilde{\mathbf{y}} &= \text{sigmoid}(\mathbf{y}(\text{idx})), \\
\tilde{X}^{\ell} &= X^{\ell}(\text{idx}, :), \\
A^{\ell+1} &= A^{\ell}(\text{idx}, \text{idx}), \\
X^{\ell+1} &= \tilde{X}^{\ell} \odot \left(\tilde{\mathbf{y}}\mathbf{1}_C^T\right),
\end{aligned}
$$



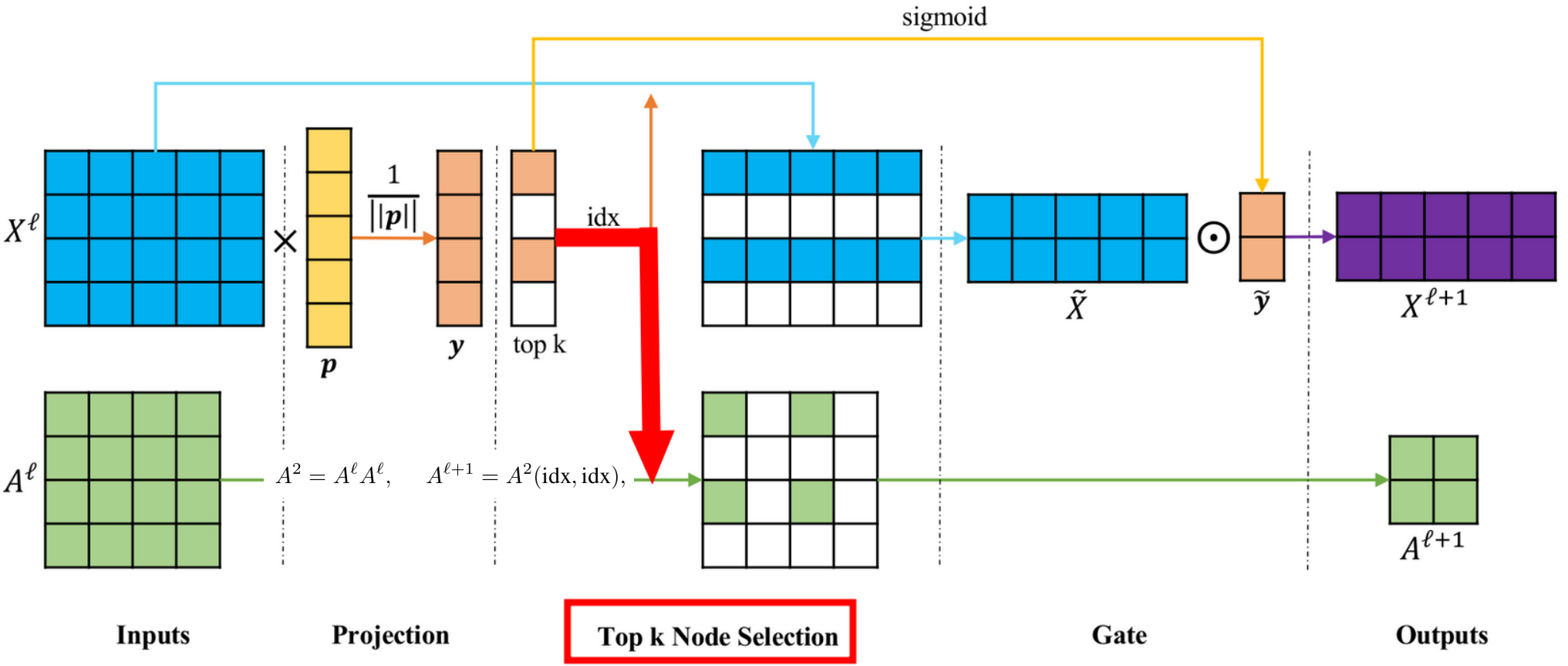
Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

gPool - Projection



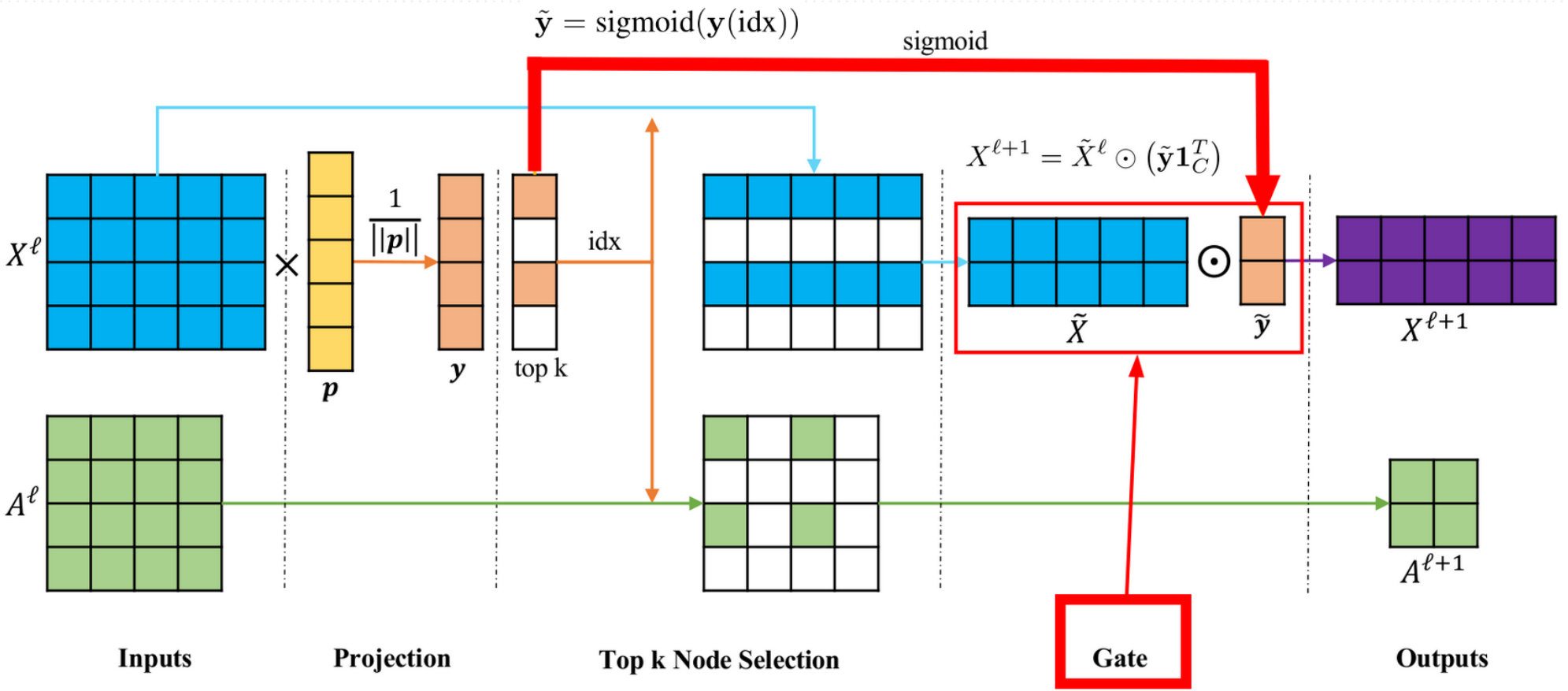
Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

gPool - Connectivity Augmentation



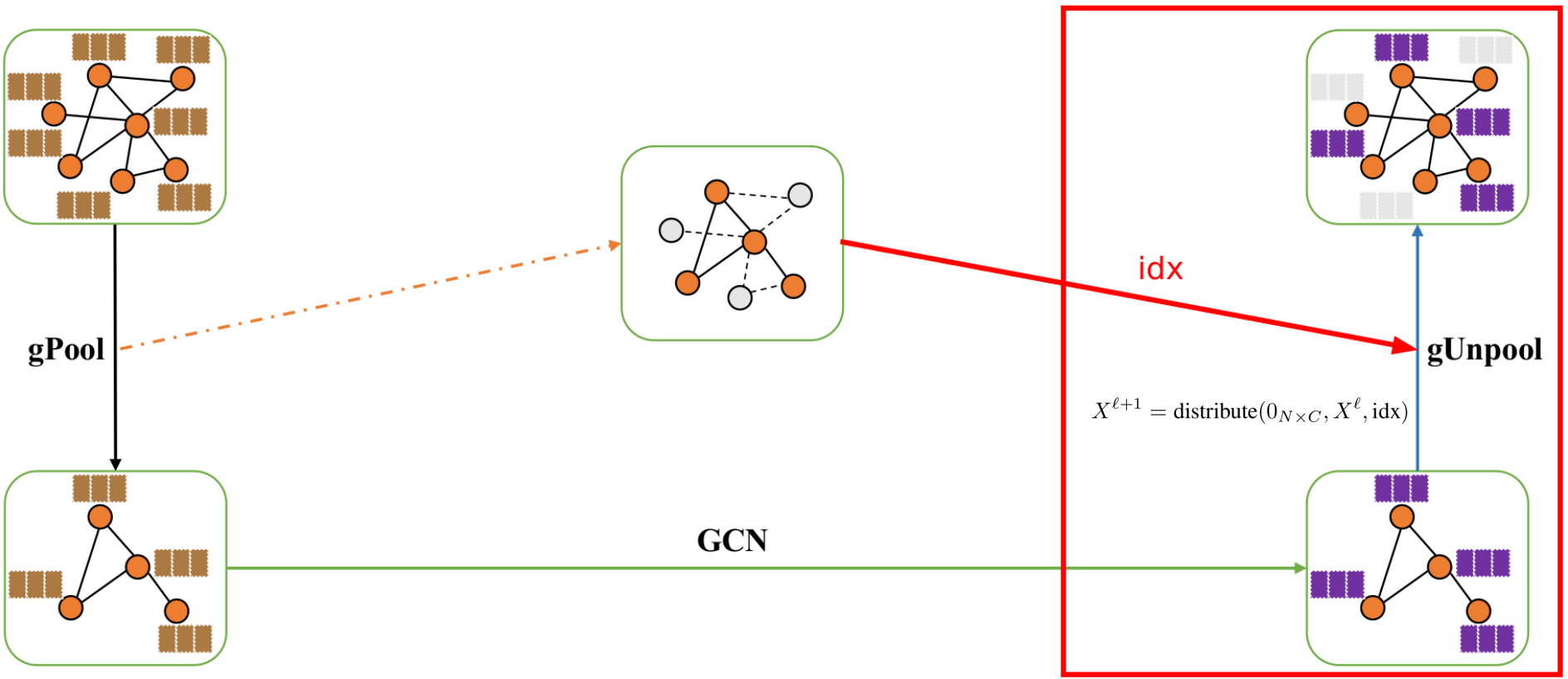
Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

gPool - Gate



Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

gUnpool

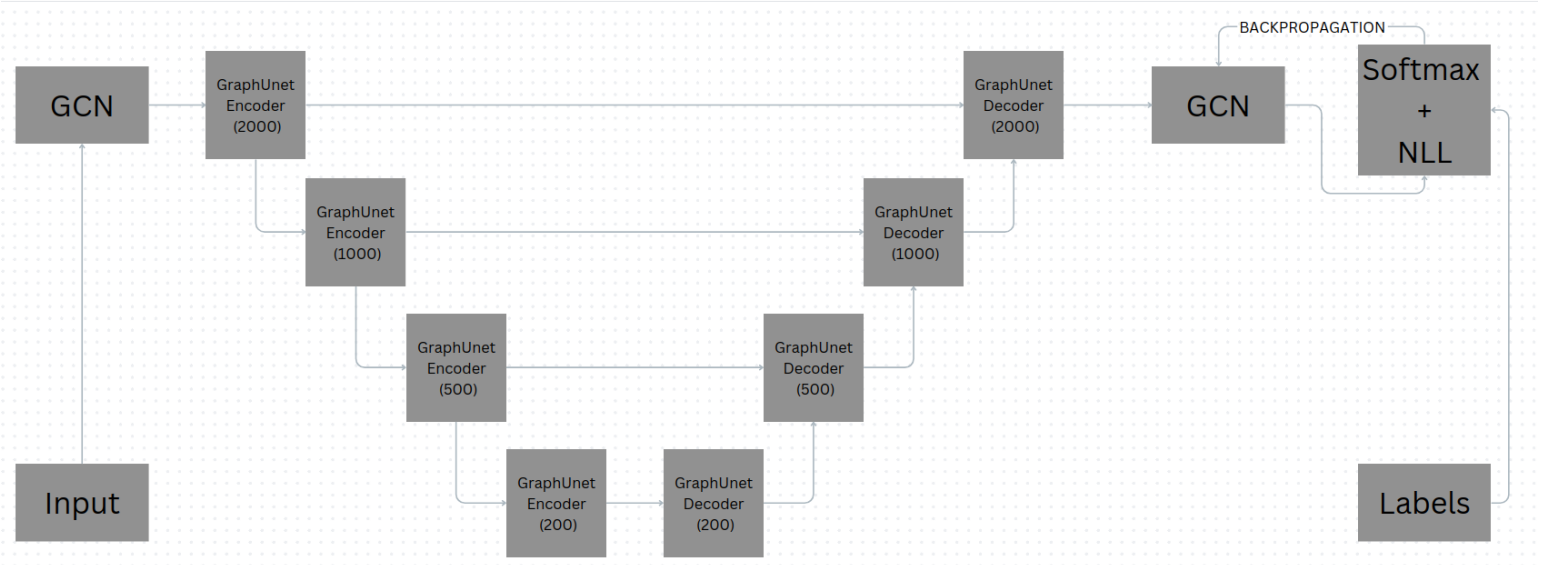


Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

Experiments

Table 1. Summary of datasets used in our node classification experiments (Yang et al., 2016; Zitnik & Leskovec, 2017). The Cora, Citeseer, and Pubmed datasets are used for transductive learning experiments.

Dataset	Nodes	Features	Classes	Training	Validation	Testing	Degree
Cora	2708	1433	7	140	500	1000	4
Citeseer	3327	3703	6	120	500	1000	5
Pubmed	19717	500	3	60	500	1000	6



Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

Experiments

Table 3. Results of transductive learning experiments in terms of node classification accuracies on Cora, Citeseer, and Pubmed datasets. g-U-Nets denotes our proposed graph U-Nets model.

Models	**Cora**	**Citeseer**	**Pubmed**
DeepWalk (Perozzi et al., 2014)	67.2%	43.2%	65.3%
Planetoid (Yang et al., 2016)	75.7%	64.7%	77.2%
Chebyshev (Defferrard et al., 2016)	81.2%	69.8%	74.4%
GCN (Kipf & Welling, 2017)	81.5%	70.3%	79.0%
GAT (Veličković et al., 2017)	83.0 ± 0.7%	72.5 ± 0.7%	79.0 ± 0.3%
g-U-Nets (Ours)	**84.4 ± 0.6%**	**73.2 ± 0.5%**	**79.6 ± 0.2%**

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Experiments

Table 5. Comparison of g-U-Nets with and without gPool or gUnpool layers in terms of node classification accuracy on Cora, Citeseer, and Pubmed datasets.

Models	Cora	Citeseer	Pubmed
g-U-Nets without gPool or gUnpool	$82.1 \pm 0.6\%$	$71.6 \pm 0.5\%$	$79.1 \pm 0.2\%$
g-U-Nets (Ours)	$\mathbf{84.4 \pm 0.6\%}$	$\mathbf{73.2 \pm 0.5\%}$	$\mathbf{79.6 \pm 0.2\%}$

Table 8. Comparison of the g-U-Nets with and without gPool or gUnpool layers in terms of the node classification accuracy and the number of parameters on Cora dataset.

Models	Accuracy	#Params	Ratio of increase
g-U-Nets without gPool or gUnpool	$82.1 \pm 0.6\%$	75,643	0.00%
g-U-Nets (Ours)	$\mathbf{84.4 \pm 0.6\%}$	75,737	0.12%

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Experiments

Table 6. Comparison of g-U-Nets with and without graph connectivity augmentation in terms of node classification accuracy on Cora, Citeseer, and Pubmed datasets.

Models	**Cora**	**Citeseer**	**Pubmed**
g-U-Nets without augmentation	$83.7 \pm 0.7\%$	$72.5 \pm 0.6\%$	$79.0 \pm 0.3\%$
g-U-Nets (Ours)	$\mathbf{84.4 \pm 0.6\%}$	$\mathbf{73.2 \pm 0.5\%}$	$\mathbf{79.6 \pm 0.2\%}$

Table 7. Comparison of different network depths in terms of node classification accuracy on Cora, Citeseer, and Pubmed datasets. Based on g-U-Nets, we experiment with different network depths in terms of the number of blocks in encoder and decoder parts.

Depth	**Cora**	**Citeseer**	**Pubmed**
2	$82.6 \pm 0.6\%$	$71.8 \pm 0.5\%$	$79.1 \pm 0.3\%$
3	$83.8 \pm 0.7\%$	$72.7 \pm 0.7\%$	$79.4 \pm 0.4\%$
4	$\mathbf{84.4 \pm 0.6\%}$	$\mathbf{73.2 \pm 0.5\%}$	$\mathbf{79.6 \pm 0.2\%}$
5	$84.1 \pm 0.5\%$	$72.8 \pm 0.6\%$	$79.5 \pm 0.3\%$

Gao, Hongyang, and Shuiwang Ji. "Graph u-nets." international conference on machine learning. PMLR, 2019.

Q & A