Edge-Aware Graph Attention Network for Ratio of Edge-User Estimation in Mobile Networks

Jiehui Deng, Sheng Wan, Xiang Wang, Enmei Tu, Xiaolin Huang, Jie Yang and Chen Gong*

Nanjing University of Science and Technology

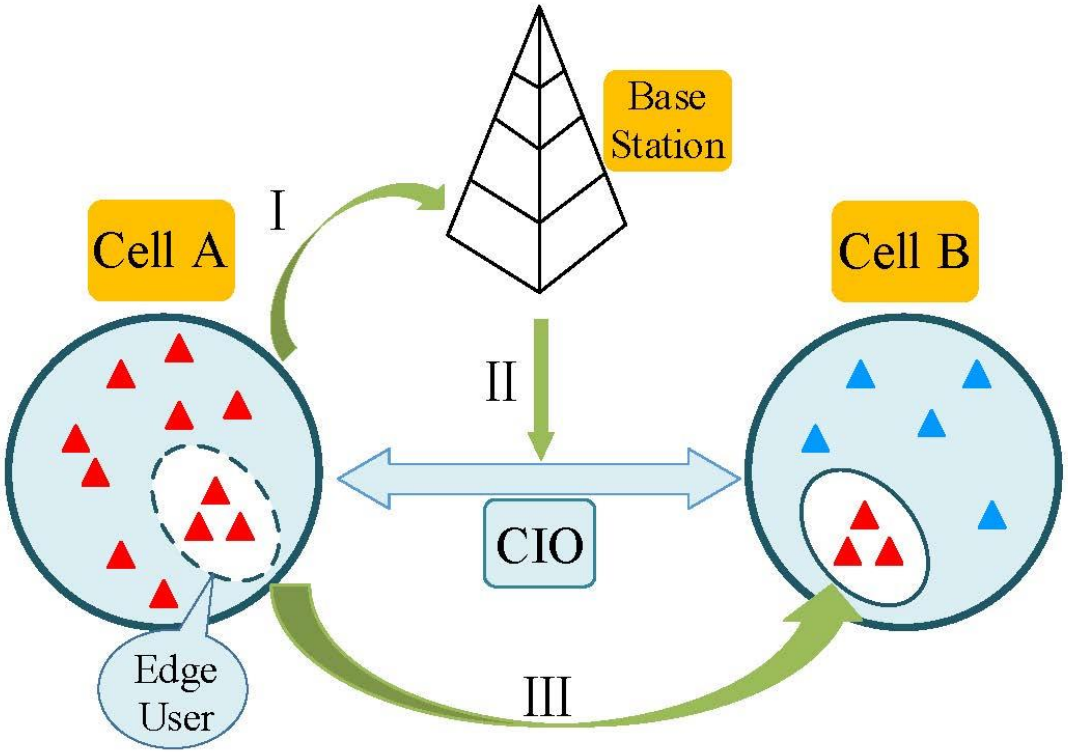
Shanghai Jiao Tong University

Outline

- Introduction
- Motivation
- Proposed method
- Experimental results

Background

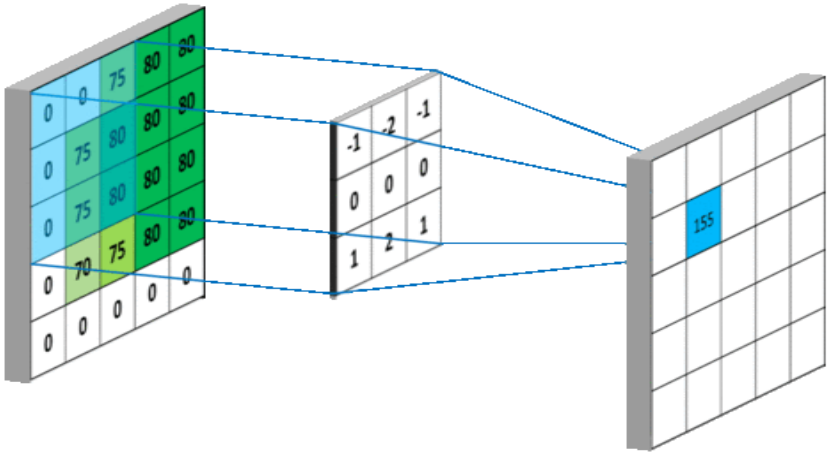
- Estimating the Ratio of Edge-Users (REU) in mobile networks.
- We Using a machine learning technique to adaptively estimate or predict the REU.

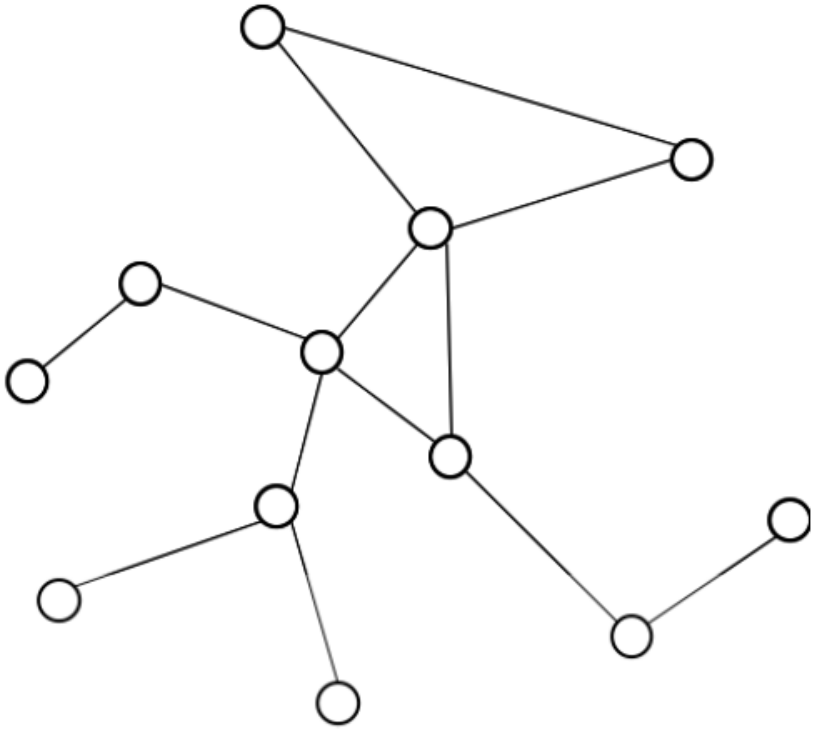


Motivation

- The mobile network naturally contains a graph structure.
- The graph edges and their features also play a critical role in determining the REU.

Graph Convolutional Network



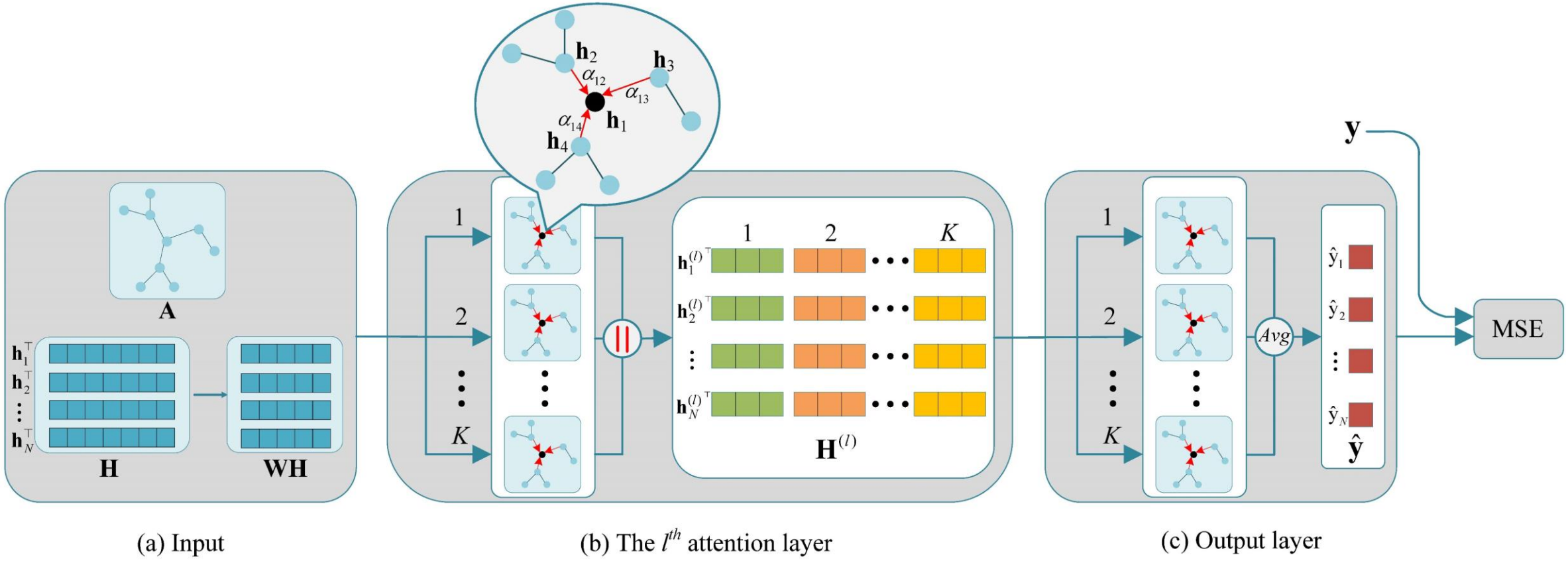


Regular domain $\xrightarrow{\text{convolution}}$ Irregular domain

Existing methods

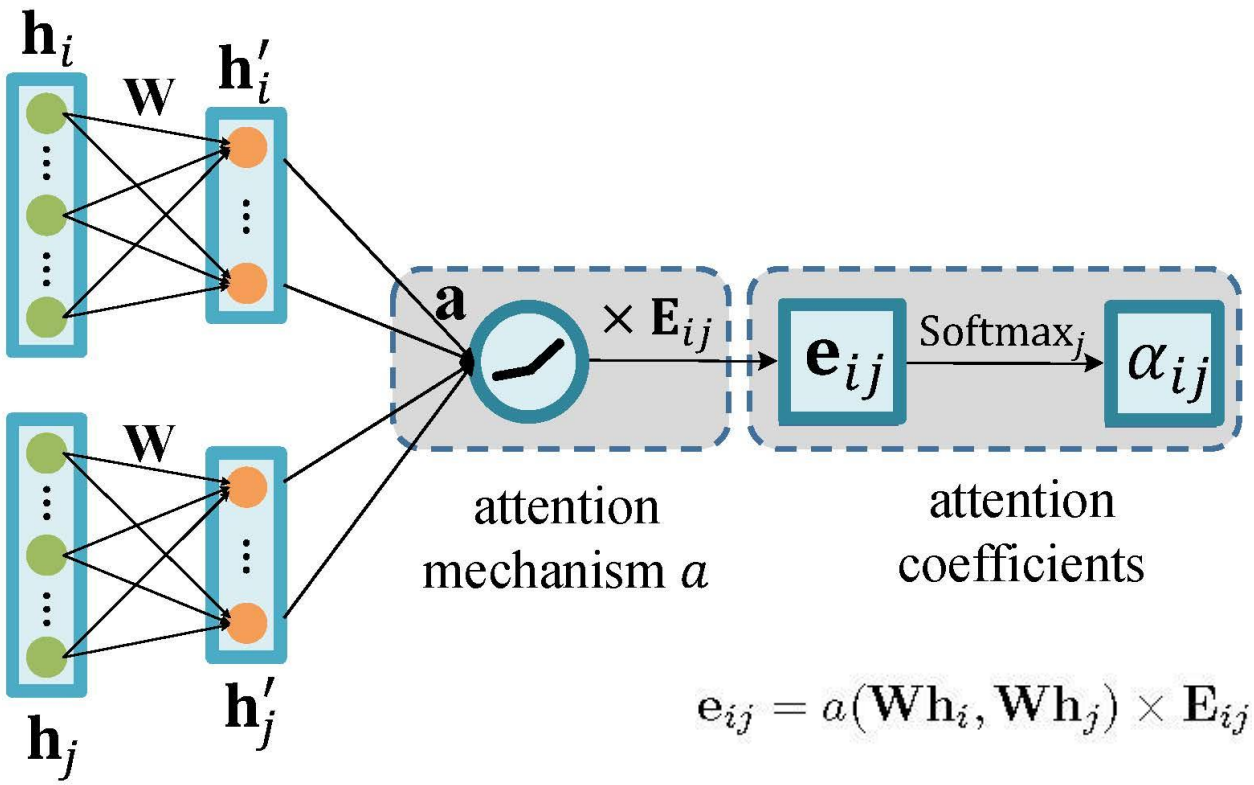
- ✓ Spectral-Based Graph Convolution
- ✓ Spatial-Based Graph Convolution
- ✓ Edge-based Graph Convolution

Proposed Method: EAGAT



Architecture

Proposed Method: EAGAT



$$\mathbf{e}_{ij} = a(\mathbf{W}\mathbf{h}_i, \mathbf{W}\mathbf{h}_j) \times \mathbf{E}_{ij}$$

$$\alpha_{ij} = \text{softmax}_j(\mathbf{e}_{ij}) = \frac{\exp(\mathbf{e}_{ij})}{\sum_{k \in \mathcal{N}_i} \exp(\mathbf{e}_{ik})}$$

$$\alpha_{ij} = \frac{\exp(\text{LeakyRelu}(\mathbf{a}^\top[\mathbf{W}\mathbf{h}_i || \mathbf{W}\mathbf{h}_j]) \times \mathbf{E}_{ij})}{\sum_{k \in \mathcal{N}_i} \exp(\text{LeakyRelu}(\mathbf{a}^\top[\mathbf{W}\mathbf{h}_i || \mathbf{W}\mathbf{h}_k]) \times \mathbf{E}_{ik})},$$

Overall algorithm

Algorithm 1 Edge-Aware Graph Convolution Process of EAGAT

Input: Input node features $\mathbf{H}$; Input edge features $\mathbf{E}$; Neighborhood $\mathcal{N}$;

```
// Calculate the attention coefficients
for i = 1, 2, ..., N do
    for j = 1, 2, ..., N do
        Obtain α_ij according to Eq. (8);
        Obtain A_ij according to Eq. (9);
    end for
end for
// Perform graph convolution
for l = 1, 2, ..., L − 1 do
    Obtain H^(l) according to Eq. (11);
end for
Calculate the network output according to Eq. (12);
```

Output: Network output $\hat{\mathbf{y}}$.

Algorithm 2 Proposed EAGAT for REU Estimating

Input: Input Graph with $\mathbf{H}$ and $\mathbf{E}$; Neighborhood $\mathcal{N}$; number of iterations T; learning rate η; number of graph convolutional layers L; number of attention heads K;

```
// Train the model
for i = 1, 2, ..., T do
    Conduct EAGAT by Algorithm 1;
    Calculate the error term according to Eq. (13), and update the weight matrices W^k_(l) (1 ≤ l ≥ L, 1 ≤ k ≥ K) using full-batch gradient descent;
end for
Conduct prediction by Algorithm 1;
```

Output: REU prediction for each node in the graph.

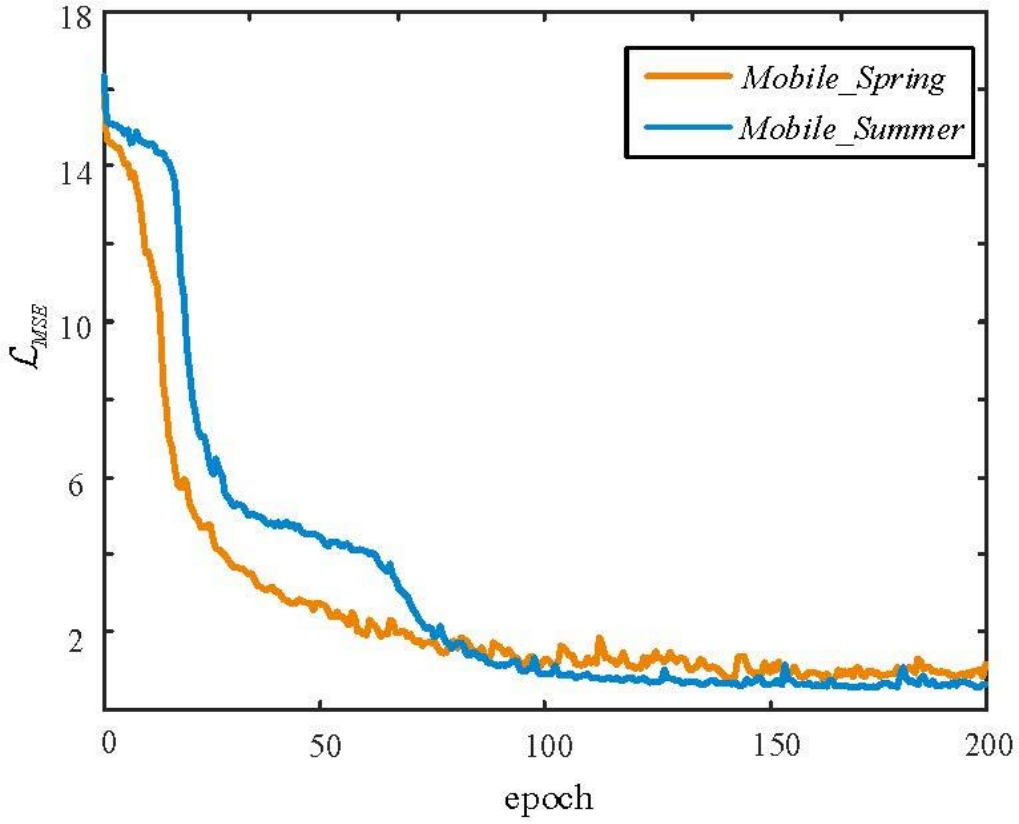
Experimental results

- Regression results

Model	*Mobile_Spring*	*Mobile_Summer*
MLP [48]	0.602 ± 0.007	0.614 ± 0.006
RF [49]	0.610 ± 0.008	0.618 ± 0.007
GraphSAGE [23]	0.702 ± 0.010	0.712 ± 0.011
GAT [15]	0.721 ± 0.007	0.734 ± 0.013
EGNN [29]	0.733 ± 0.008	0.745 ± 0.009
EAGAT	**0.880 ± 0.010**	**0.891 ± 0.008**

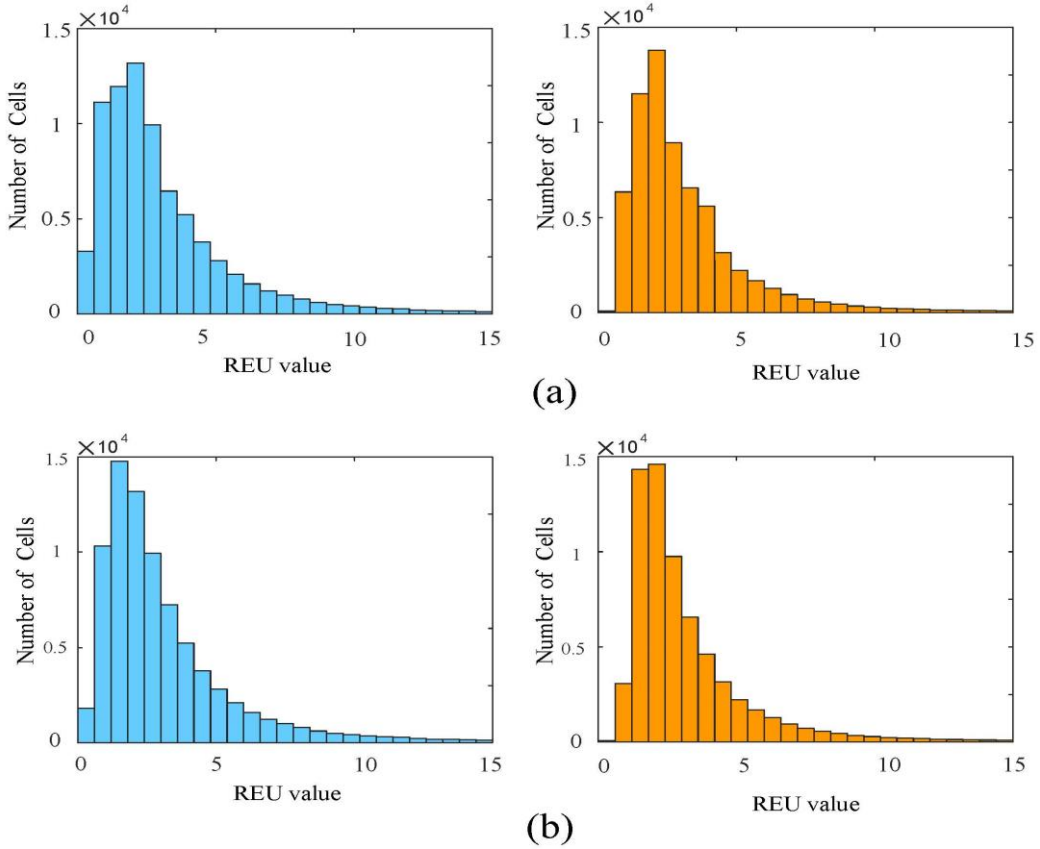
Experimental results

- The convergence curve



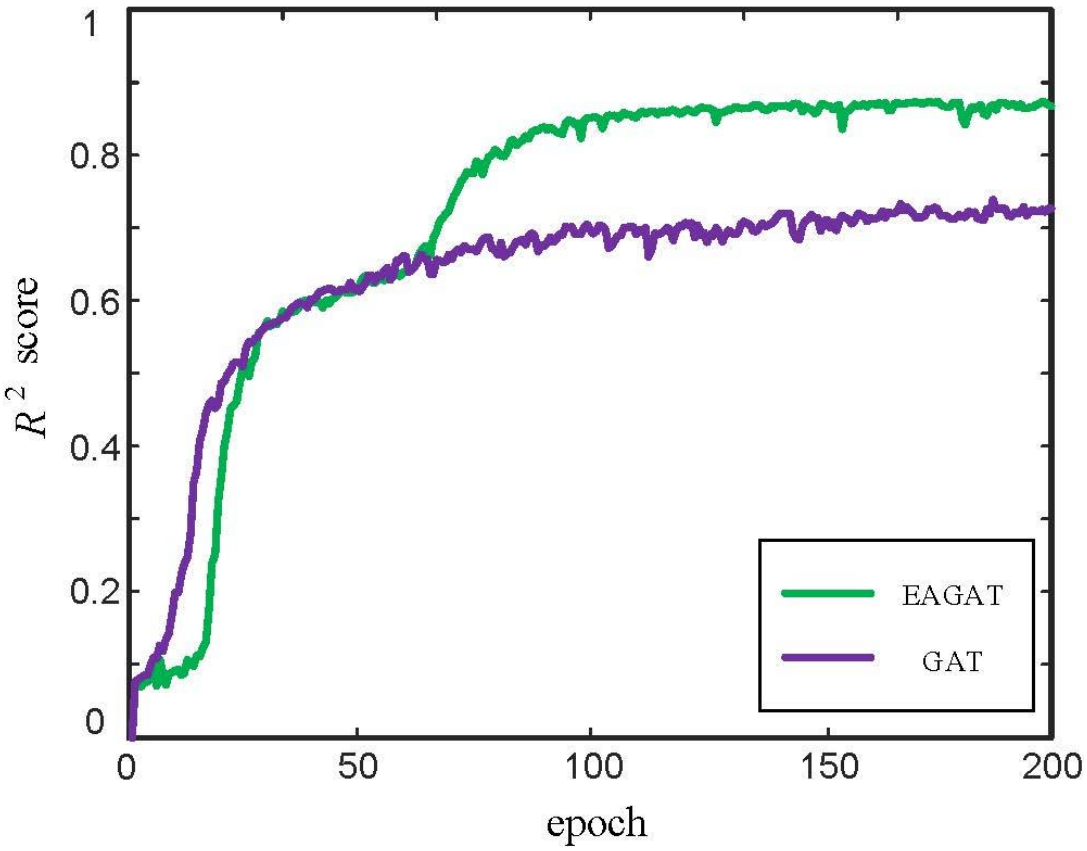
Experimental results

- Distribution



Experimental results

- Ablation Study



Thanks for your attention!

jhdeng@njust.edu.cn