Encode Graph of Graphs

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Agenda

- Introduction and Background
- Graphs
- Graph of Graphs (GoGs)
- Encode Graphs
- Encode Graph of Graphs
- Experimental Results
- Future Work
- Conclusion

Background

- Thesis title: Impact Sensitive Ranking of structured documents.
- This project aims to provide an alternative to ranking documents in a structured domain.

Tasks:

- Find a suitable methodology for extracting document structure
- **Find a suitable methodology for modelling structured information**
- Apply methods to structure with the aim to rank documents by impact

Background

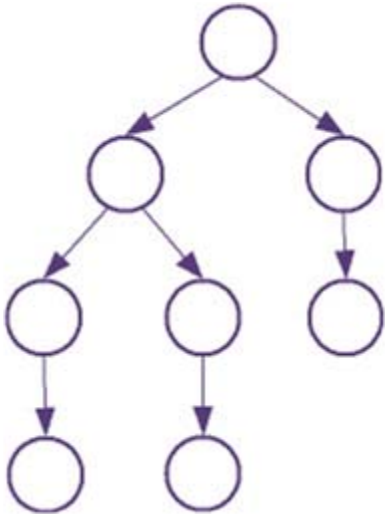
- The emergence of neural network models are capable to encode topological information when dealing with structural data. e.g. RCC, BPTS, GNN, SOMSD, GraphSOM, PM-GraphSOM.
- These methods are limited to process graphs which can be represented by labeled nodes and labeled links. i.e. node label must be real valued vector with fixed dimension.
- However, real world learning problems require the encoding of a graph structure whose node can also be a graph. e.g. web graph.

Introduction

- A novel representation of a general class of structured information, i.e. Graph of Graphs (GoGs).
- Modified Back Propagation Through Structure training algorithm to be used to train such a GoGs structure.
- Experimental results on artificial benchmark problem and real world XML mining task indicated that the learning is effective.

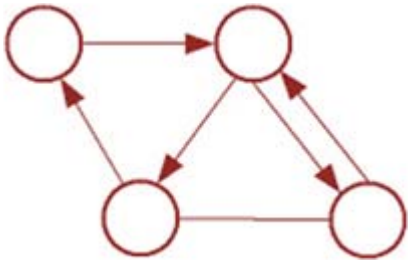
Graph

- Trees
  - Each node has only one parent node, 0 or more children.
  - No cycles.



- Sequences

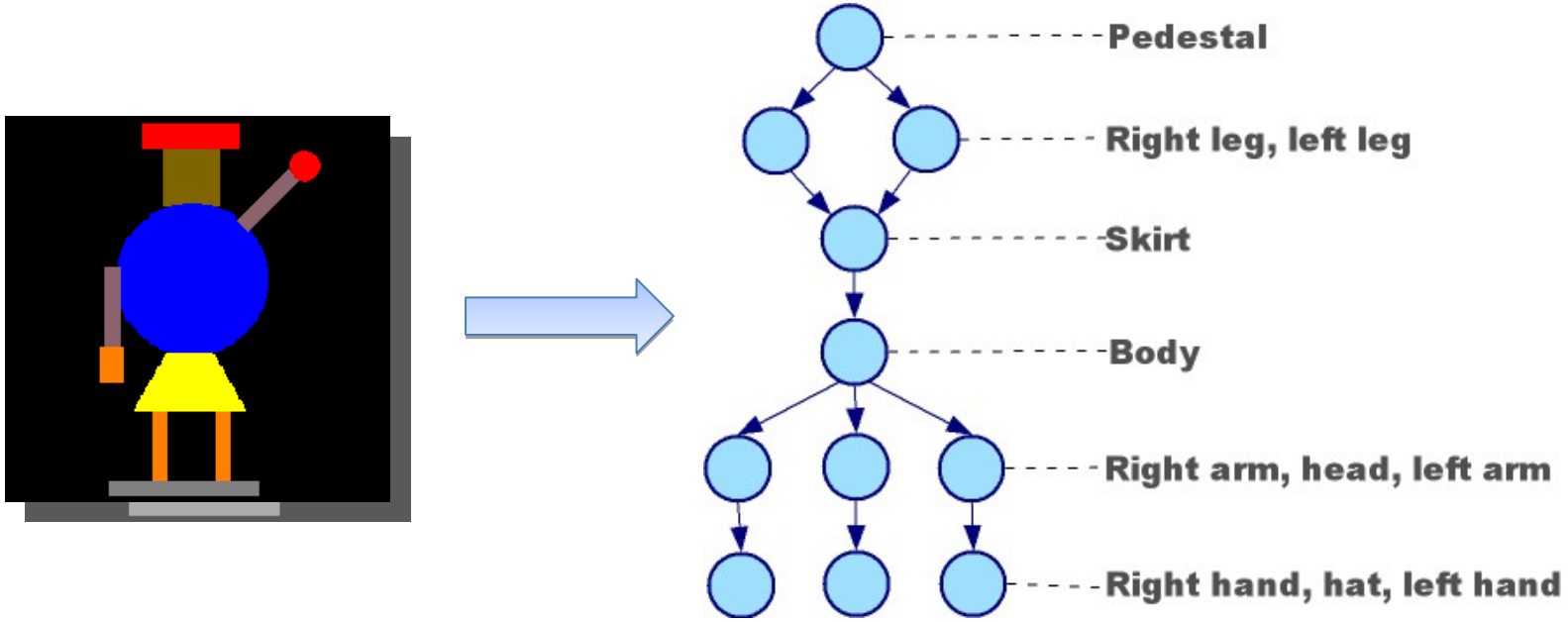
- Graphs
  - Cycles
  - Undirected links
  - Bi-directed links



Graph

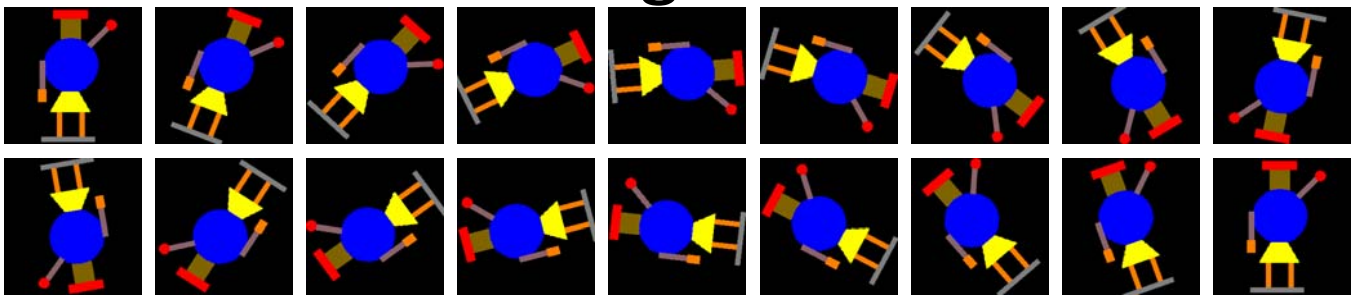
- Policeman Benchmark

Dataset of images featuring policeman, houses and ships which were generated by an attributed plex grammar.



Graph of Graphs

- Movement (sequence of trees)
  - Clockwise rotating

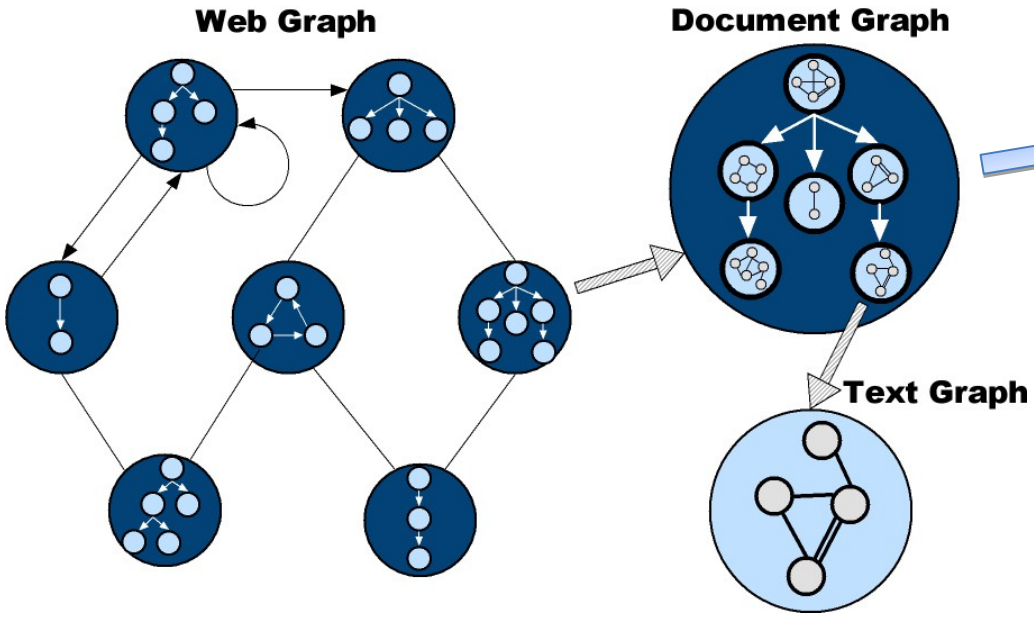


- Similarly,
  - Move arms up/down
  - Zoomin/Zoomout
  - etc

Graph of Graphs

➢ Web graph

• Documents are connected through links. e.g. Hyperlinks, citation, etc.
• Each document has its internal structure. e.g. XML structure, concept link graph, etc.
• There exist relationship between sentences or words. e.g. sentence syntax graph, text graph, etc.



XML structure

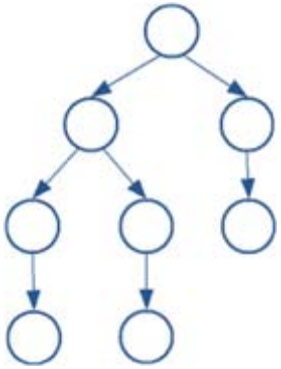
```
<article>
  <head>
    <title>…</title>
  </head>
  <name>…</name>
  <body>
    <item></item>
  </body>
</article>
```

Encode Trees

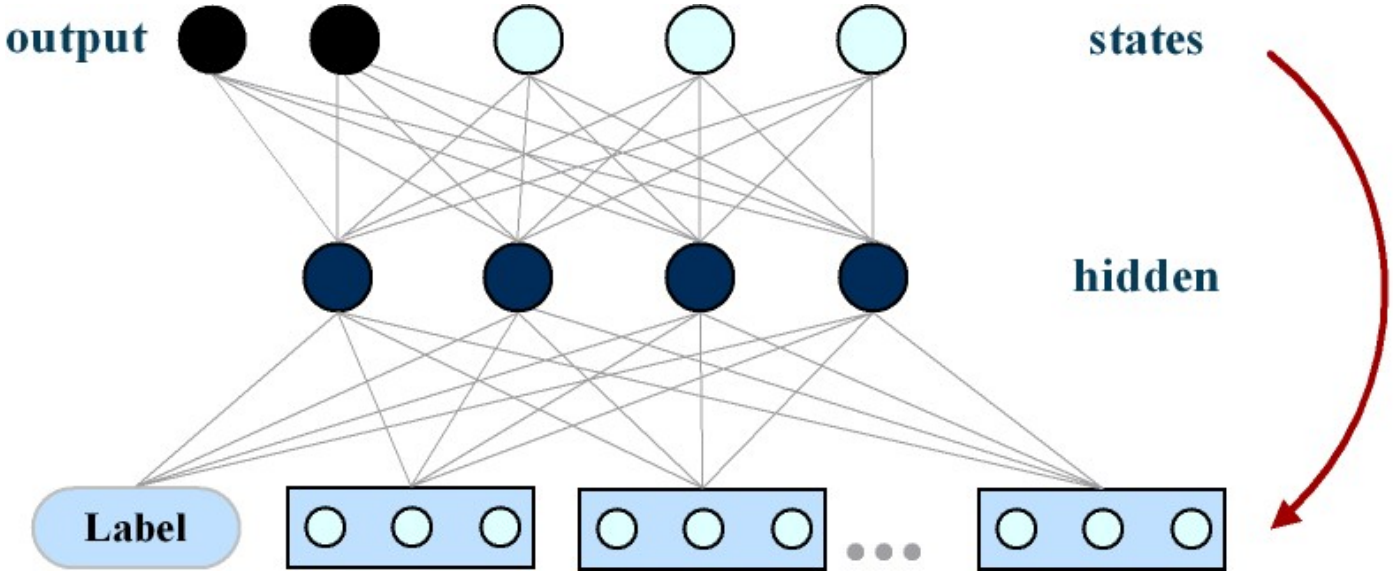
- BPTS (Back propagation through structure)

Components: Input, Hidden, State, Output

- Deal with directed ordered graphs



- Attach state output of children nodes as input
- Forward from leaf nodes to root node
- Propagate errors back from root node to leaf nodes



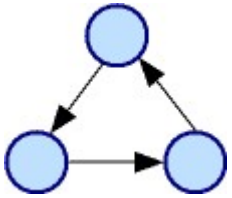
Encode Graphs

- Extended BPTS

BPTS Extention which allows processing of:

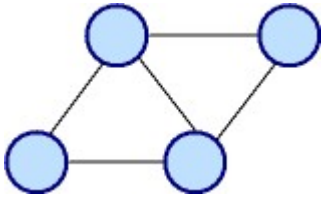
- Directed unordered graphs

Attach state outputs of both parent and children nodes as input.



- Undirected graphs

Attach state outputs of neighboring nodes as input.



Encode Graphs

- Forward phase

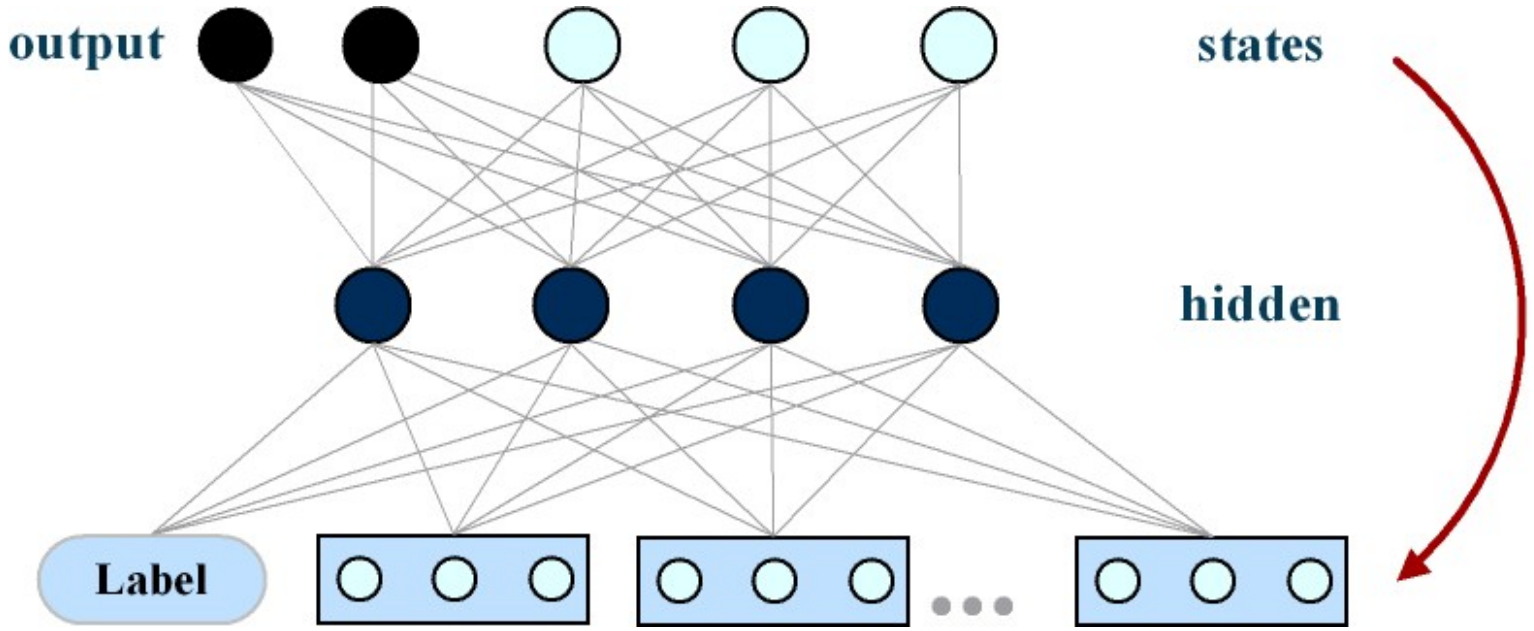
  Process nodes at random order, and iteratively compute outputs until the state outputs converge.

- Backward phase

  Process nodes at reversed order, and propagate errors back through unfolded network architecture.

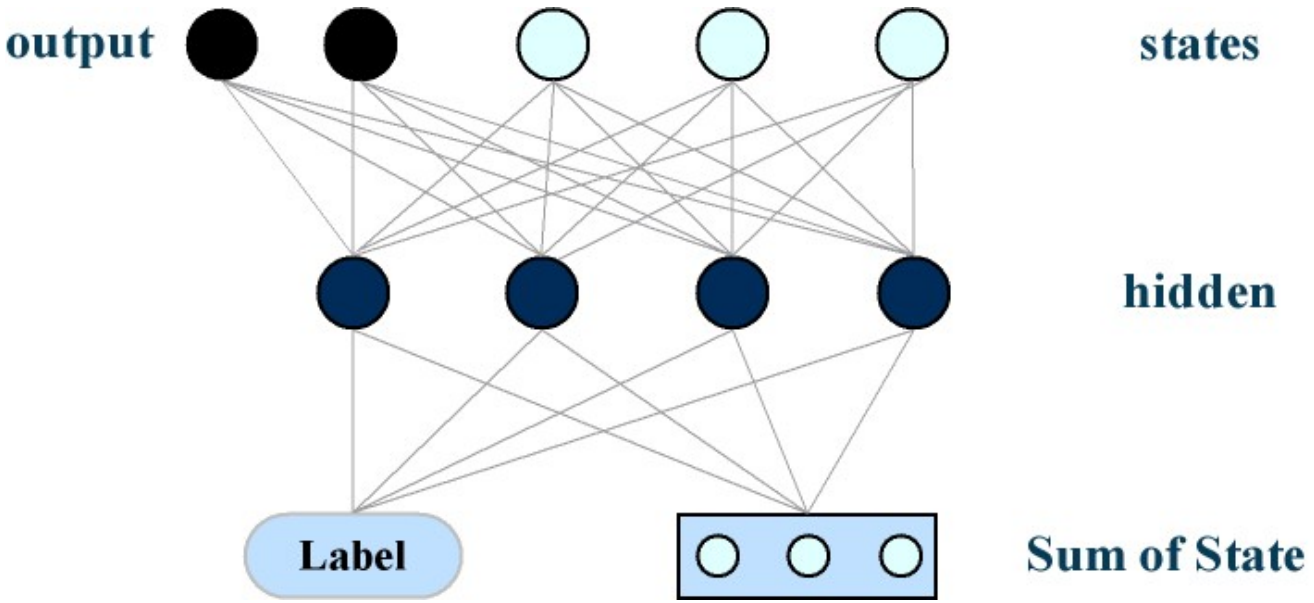
Encode Graphs

- In order to train a dataset, the maximum in-degree, out-degree or maximum number of neighbors is required to be known.
- Use individual state



GNN Training algorithm

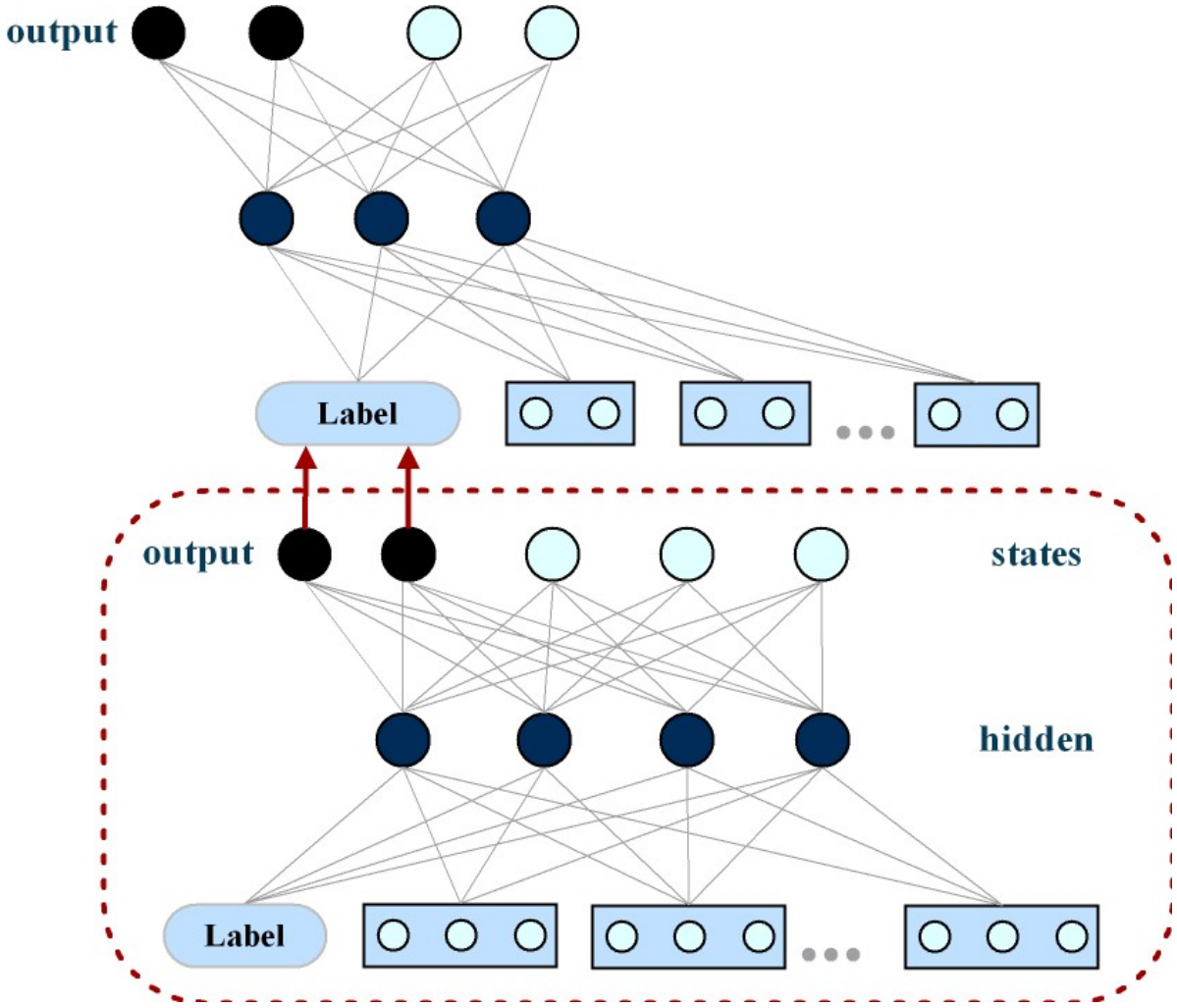
- In order to train a dataset, the maximum in-degree, out-degree or maximum number of neighbors should be known.
- Use sum of state



Encode Graph of Graphs

➢ BPTS2

- First extended BPTS is an encoding network used to encode individual graphs.
- Second extended BPTS is an output network used to produce outputs for GoG. Take the outputs from encoding network as the input labels.
- The error computed between target and output will be propagated back through output network and then encoding network.



Experiment Results

- Method: Extended BPTS
- Dataset

•Policeman benchmark
•1500 graphs
•3 classes: policeman, houses and ships
•Input=2, output=3, maxout=6, maxin=2

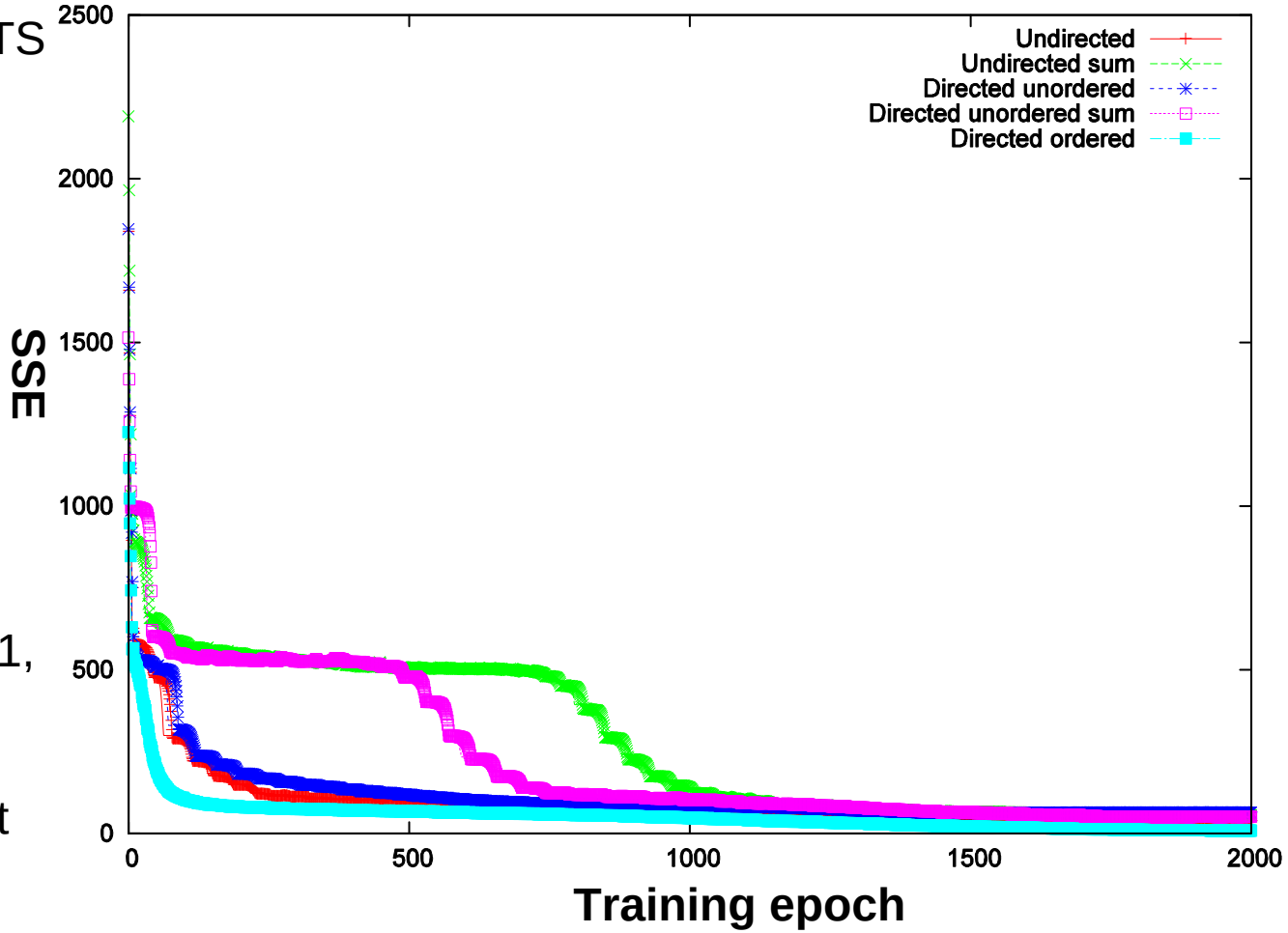
- Network

State=3, hidden=4

- Training configuration

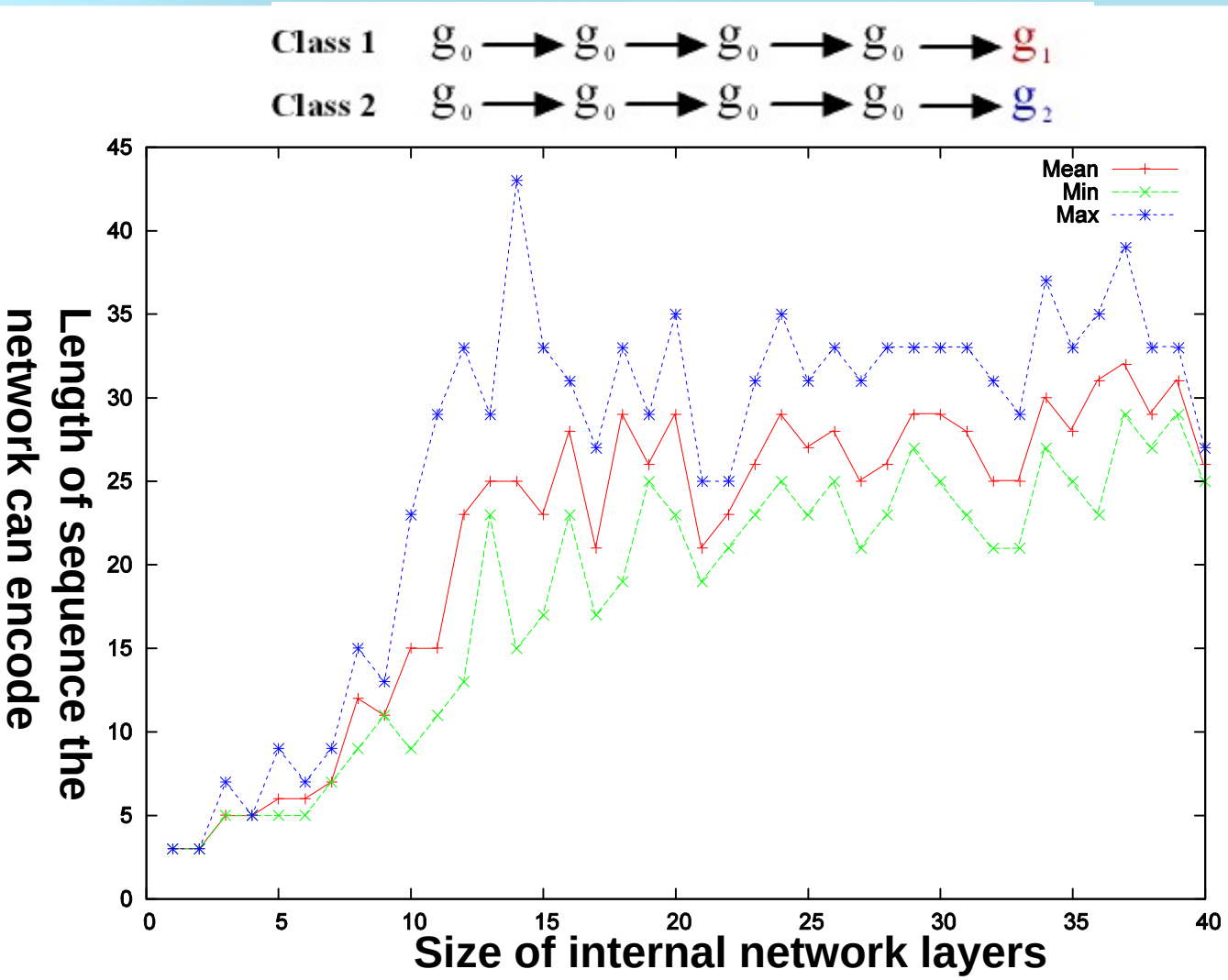
eta=0.04, costbonus=0.01, epoch=2000

- All curves converged during training in different speed.



Experiment Results

- Concurrently increase the number of neurons on all internal network layers.
- The network's capability to encode deep structure increases significantly to 32.
- The experiment also confirmed that 15 to 20 neurons on each internal network layer are good choice when encoding deep structure is required.



Future Work

- Find a suitable methodology for extracting document structure.
- Find a suitable methodology for modelling structured information

Apply the extended supervised model to real world problems.

- Web graphs

- Scientific documents

- Apply methods to structure with the aim to rank documents by impact

Conclusion

- Graph of graph model which is a novel representation of structured information is introduced, where the node of a graph could be described as another graph.
- BPTS(Back propagation through structure) approach has been extended to handle the training of embedded structure information and discriminate GoGs as desired.
- Long term dependency problem may not be a limiting issue for most practical training problem by using this extended method.

Reference

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Questions?

Thanks