Extraction of Airways using Graph Neural Networks

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Abstract

We present extraction of tree structures, such as airways, from image data as a graph refinement task. To this end, we propose a graph auto-encoder model that uses an encoder based on graph neural networks (GNNs) to learn embeddings from input node features and a decoder to predict connections between nodes. Performance of the GNN model is compared with mean-field networks in their ability to extract airways from 3D chest CT scans.

Graph Neural Networks

- Neural networks directly operating on graph structured data
- Generalisation of message passing algorithms
- End-to-end trainable using message passing
- Learn node embeddings for inductive and transductive tasks

Graph Refinement Model using GNN

Objective: Predict output adjacency matrix corresponding to the underlying airway tree based on node features

- Graph auto-encoder based model [1]
- Encoders comprised of Graph Convolution Layers
- Radial basis decoder outputs predicted adjacency from learnt embedding

Data

- 3-D chest CT scans from Danish Lung Cancer Screening Trial
- 24 + 8 scans for training and test, respectively
- Manually verified reference segmentations
- Bayesian smoothing based pre-processing [2]

Experiments & Results

- Compared with Mean-field Networks (MFNs) [3]
- Coarse segmentations from output graphs to extract centerlines
- Centerline distance as error measure

<table>
<thead>
<tr>
<th>Method</th>
<th>(d_{FN}(mm))</th>
<th>(d_{FP}(mm))</th>
<th>(d_{err} (mm))</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFN</td>
<td>2.571</td>
<td>0.835</td>
<td>1.703 ± 0.186</td>
</tr>
<tr>
<td>GNN</td>
<td>2.900</td>
<td>3.913</td>
<td>3.02 ± 0.386</td>
</tr>
<tr>
<td>GNN+MFN</td>
<td>2.014</td>
<td>3.315</td>
<td>2.679 ± 0.264</td>
</tr>
</tbody>
</table>

Performance comparison using centerline distance with MFNs

Conclusion

- Preliminary work on using graph refinement for airway extraction
- GNN+MFN predictions show improvements over MFN
- GNN model currently suffers from higher false positives
- Improvements are seen with additional data

Future Work:

- Data augmentation
- Attention layers to focus on specific node neighbours
- Use edge representation based GNN

Acknowledgements

This work was funded by the Independent Research Fund Denmark (DFF) and SAP SE Berlin.

References