Learning with Graphs: Networks Embedding Algorithms

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Outline

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Motivation

In order to apply machine learning models for graphs, we need to transform the vertices of a graph into a vector form. **By doing that we can take advantage of all ML algorithms (such as deep learning approaches) already developed to perform learning on graphs.**

We are going to compare three graph embedding techniques: DeepWalk, Node2Vec and Graph Convolutional Networks.

Problem Statement

Given three graph datasets: Facebook Large Page-Page Network, Github Social Network, and Cora, we will test and compare different graph embedding techniques: DeepWalk, Node2Vec on the Facebook y GitHub datasets, and Node2Vec and and Graph Convolutional Networks (GCN) on the CORA dataset.

We perform semi-supervised learning in order to guess features of nodes in a graph.

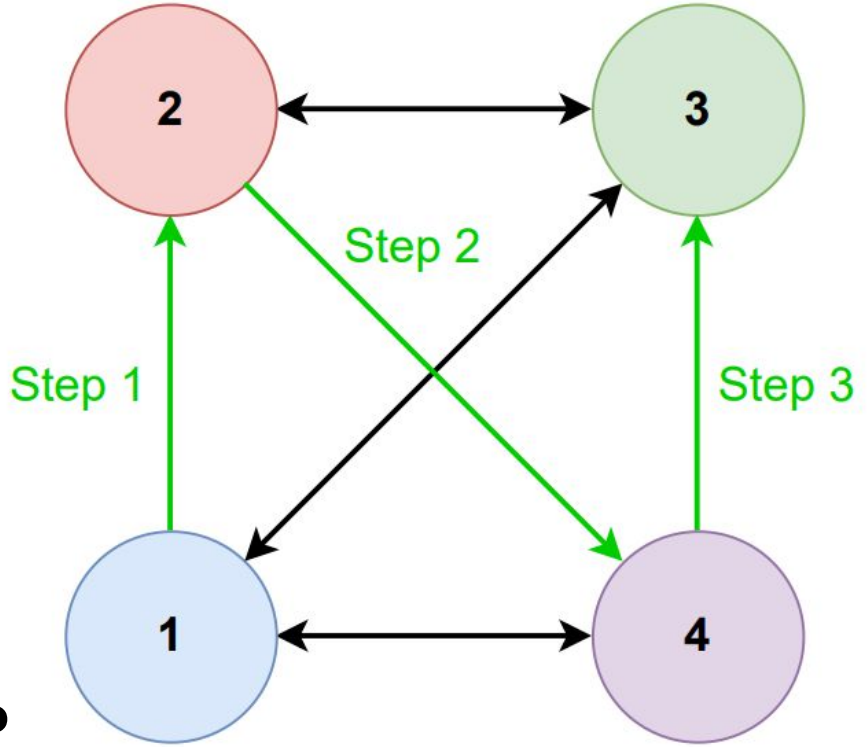
1.
Deep Walk

DeepWalk

- Run through the graph randomly
- Walks per node
- Walk Length

Walk Set: [''1'', ''2'', ''3'', ''4'']

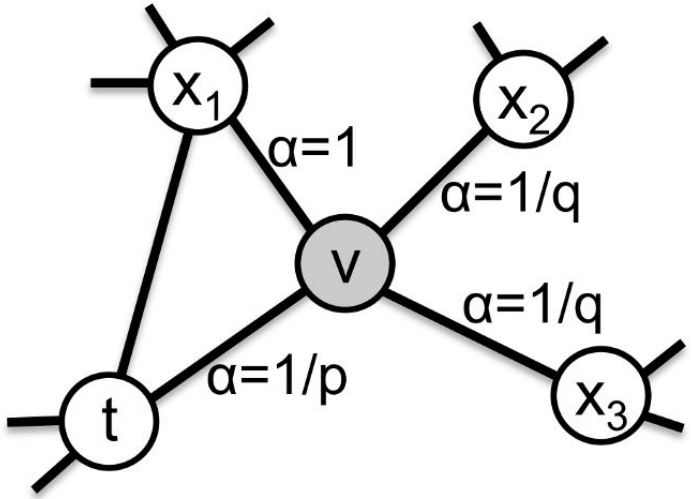
Deep Learning classification model to predict the context: Skip-gram Model



2.
Node2Vec

Node2Vec

- Biased Random Walker
  - P: Return Hyperparameter
  - Q: Inout Hyperparameter

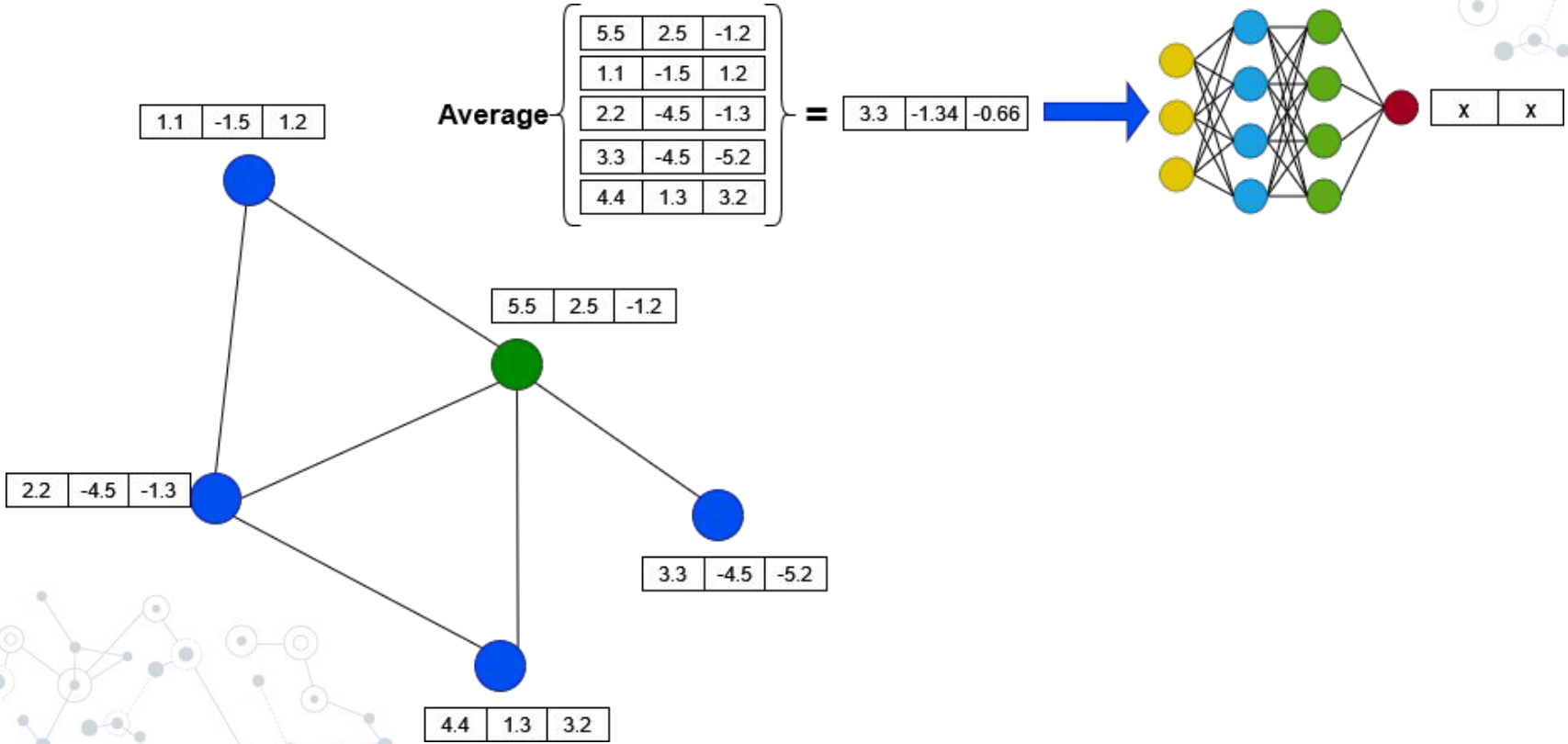


Grover, A. (2016). Node2Vec: Scalable Feature Learning for Networks. [Figure]. Recovered from: https://arxiv.org/pdf/1607.00653.pdf

3.

Graph Convolutional Networks (GCN)

GCN


1.1 -1.5 1.2
Average
5.5 2.5 -1.2
1.1 -1.5 1.2
2.2 -4.5 -1.3
3.3 -4.5 -5.2
4.4 1.3 3.2
=
3.3 -1.34 -0.66
X X
5.5 2.5 -1.2
2.2 -4.5 -1.3
3.3 -4.5 -5.2
4.4 1.3 3.2

4. Experimental Results

4.1

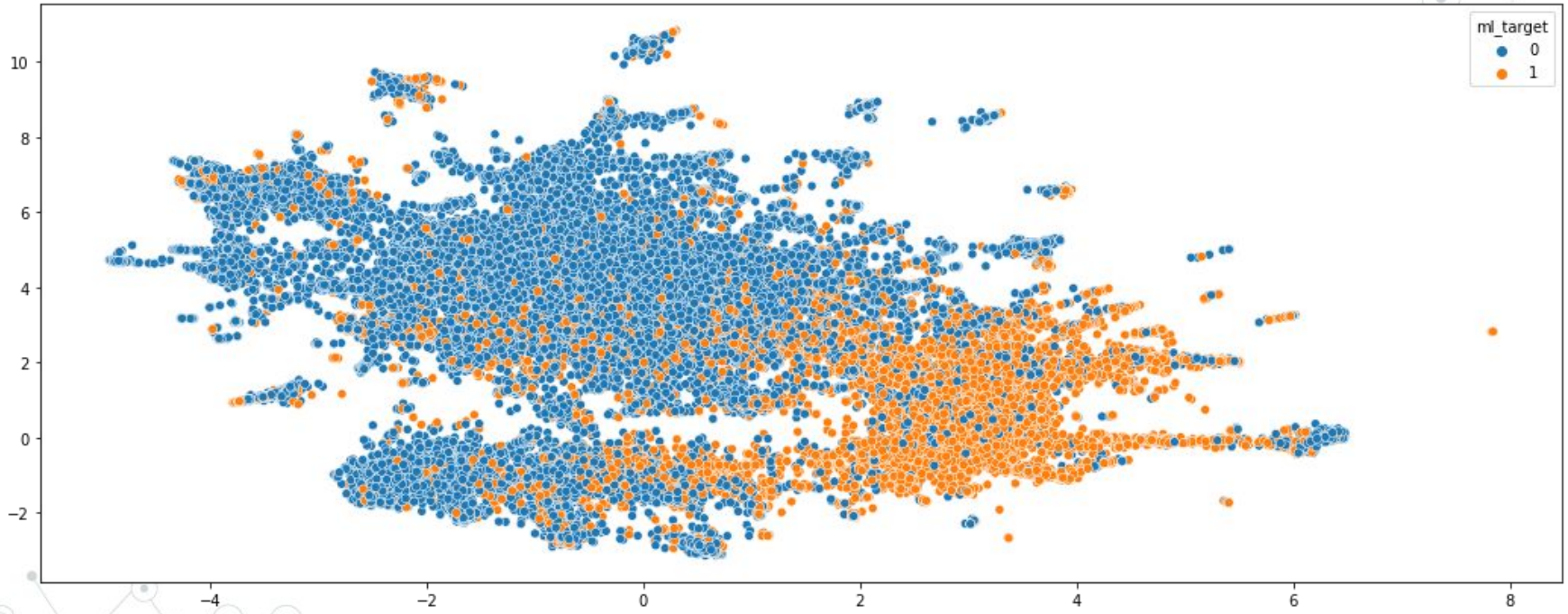
Github Dataset

Github Dataset

- Nodes are developers who have at least 10 repositories on github.
- Edges are mutual follower relationships between the developers.
- Features are extracted based on the location, employer and e-mail address.
- Nodes: 37,700: 27,961 Web Dev, 9,739 ML Dev.
- Edges: 289,003.
- Predict if a GitHub user is web or machine learning developer.

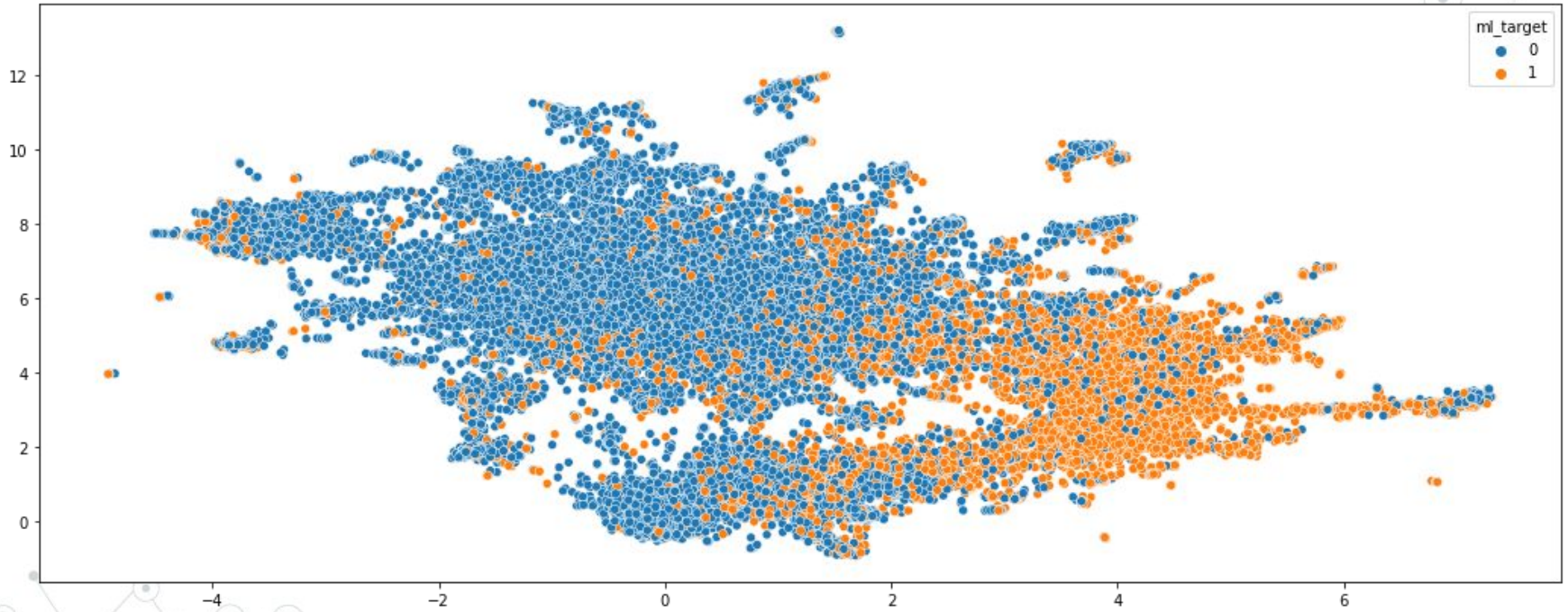
Source: https://github.com/benedekrozemberczki/datasets

Github Dataset - DeepWalk Embedding



Walks per node = 10, walk length = 80

Github Dataset - Node2Vec Embedding



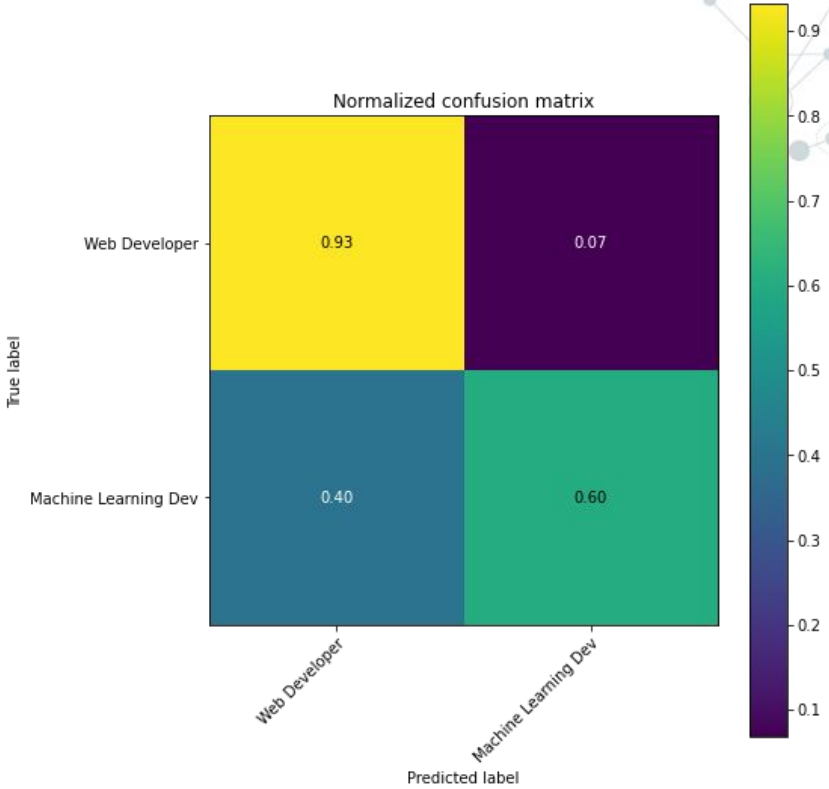
Walks per node = 10, walk length = 80, p = 0.25, q = 0.25

Github Dataset Results

DeepWalk

F1 Score: 0.8407

Walks per node = 10, walk Length = 80



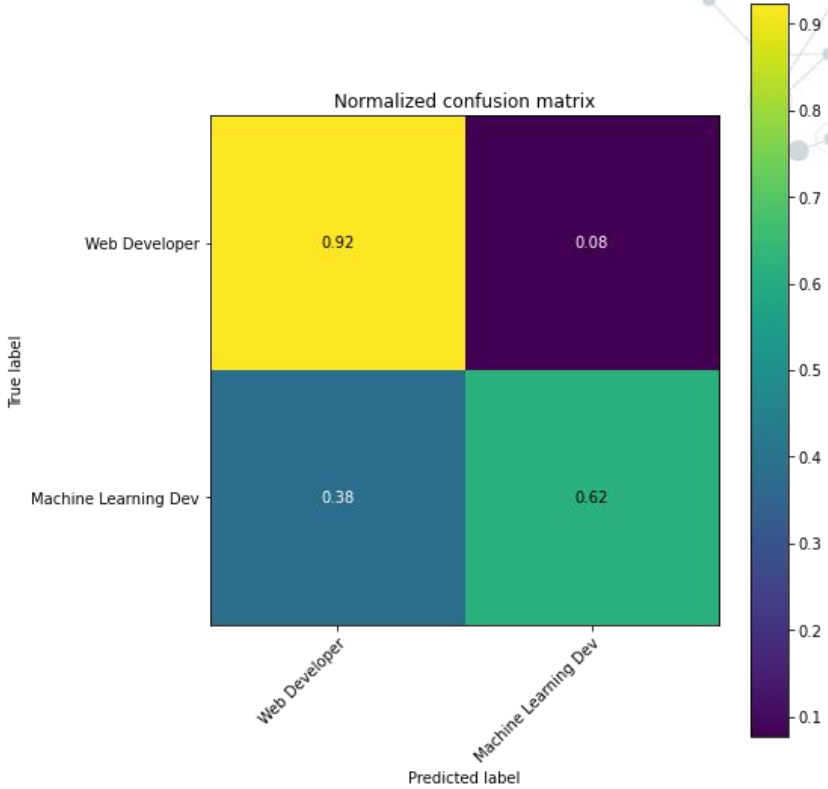
Github Dataset Results

Node2Vec

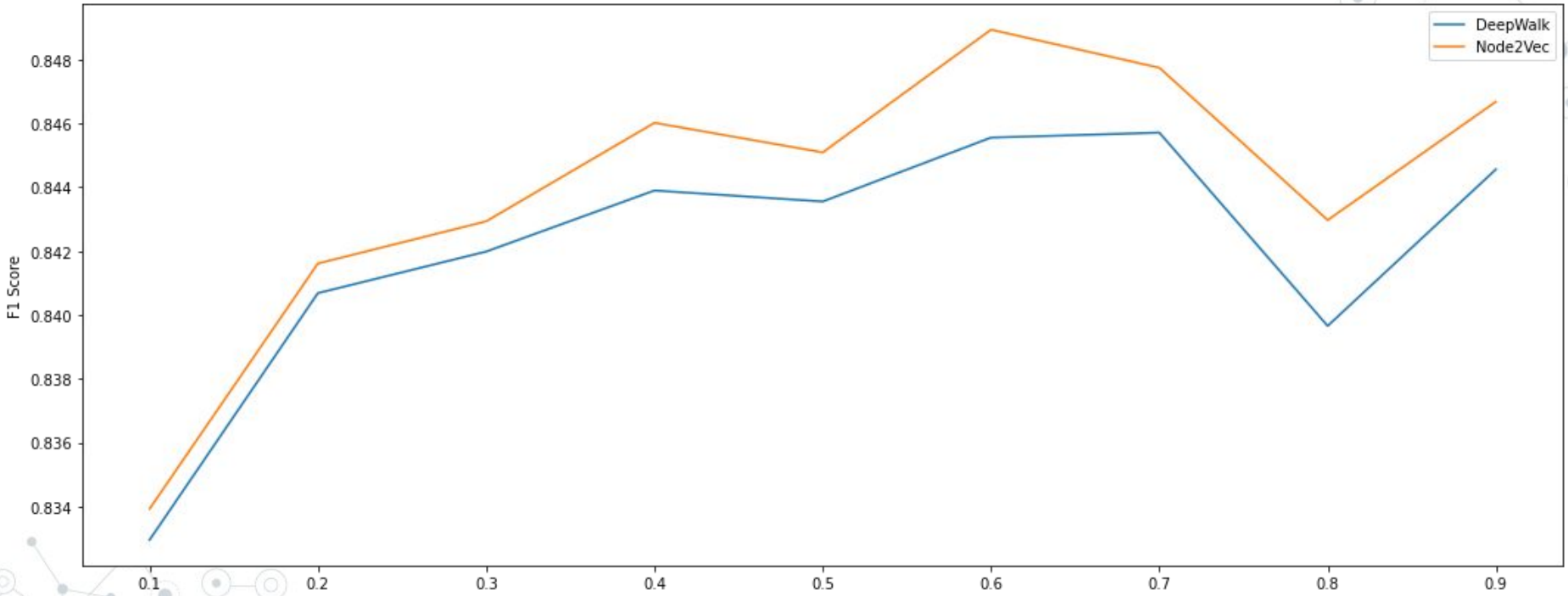
F1 Score: 0.8448

Walks per node = 10, walk Length = 80

p = 0.25, q = 0.25



Github Dataset Results



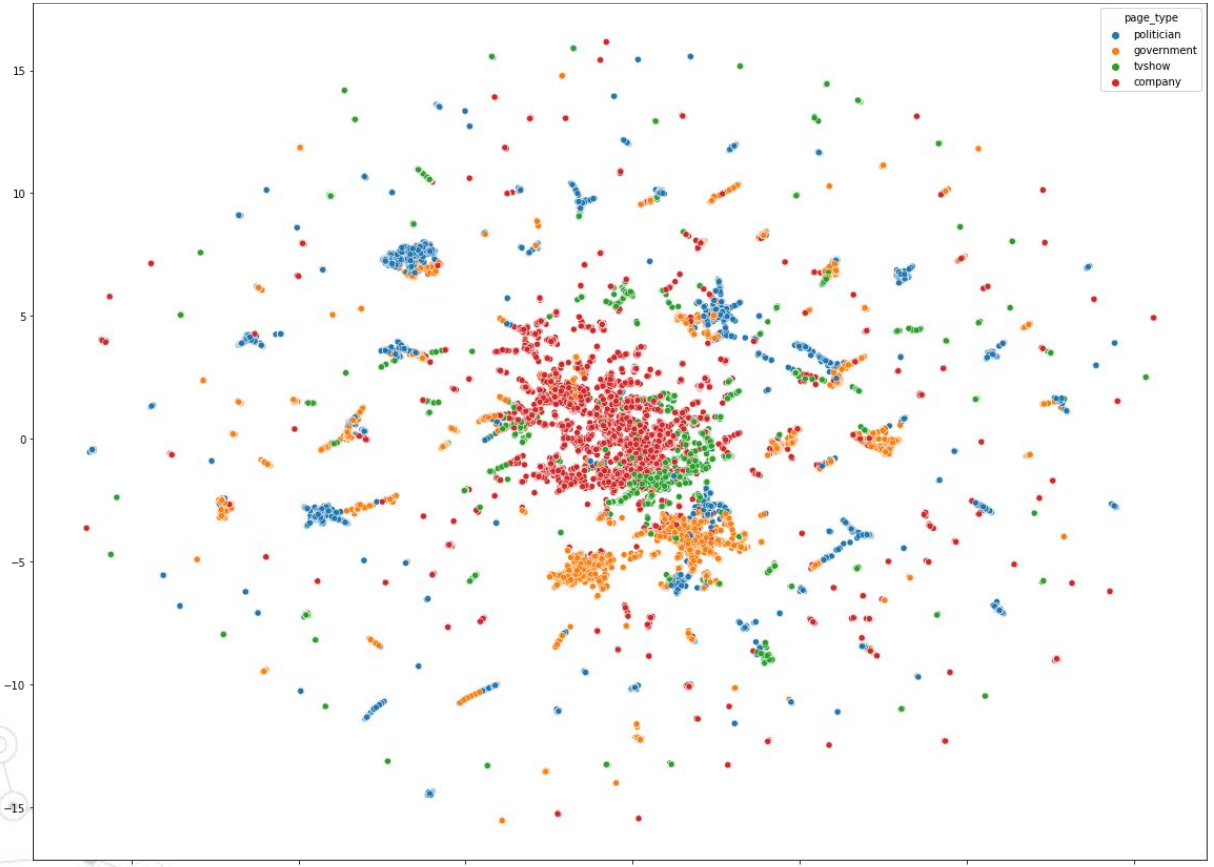
Source Code: https://github.com/julioegb/DeepWalk_vs_Node2Vec

4.2
Facebook Large Page-Page Network

Facebook Large Page-Page Network

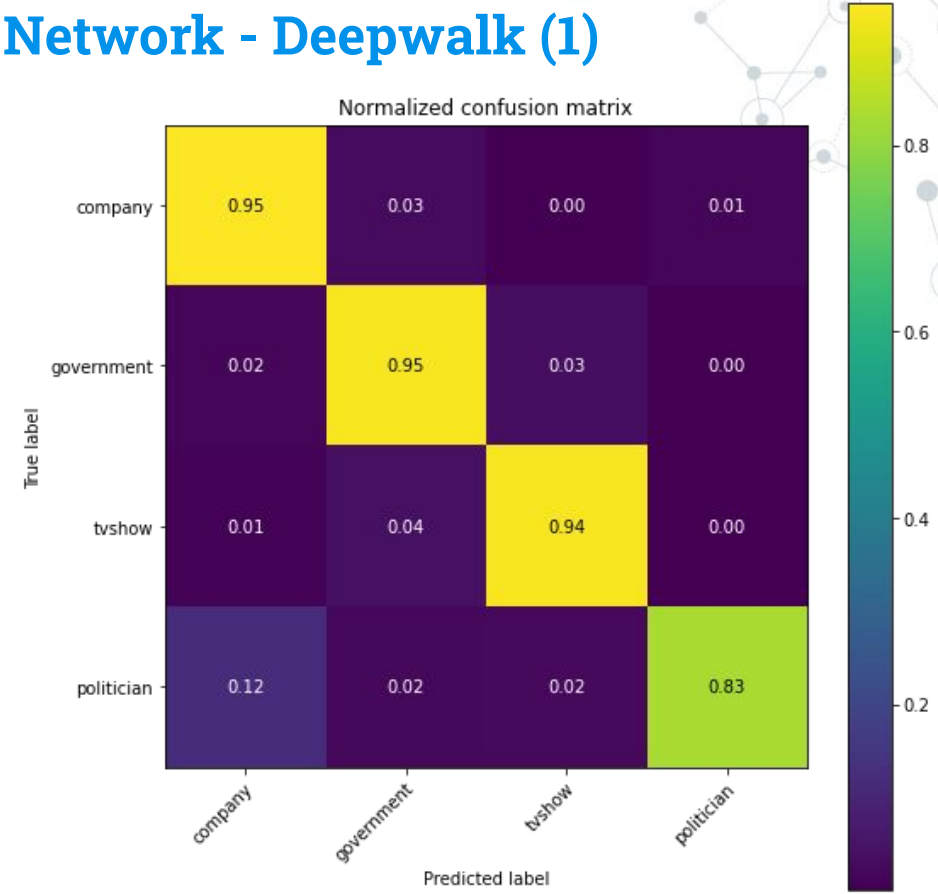
- Nodes: 22,470
- Edges: 171,002
- Categories:
  - Politicians
  - Governmental Organizations
  - Television Shows
  - Companies
- Features are the site descriptions that summarize the purpose of the site.

Facebook Large Page-Page Network - Deepwalk



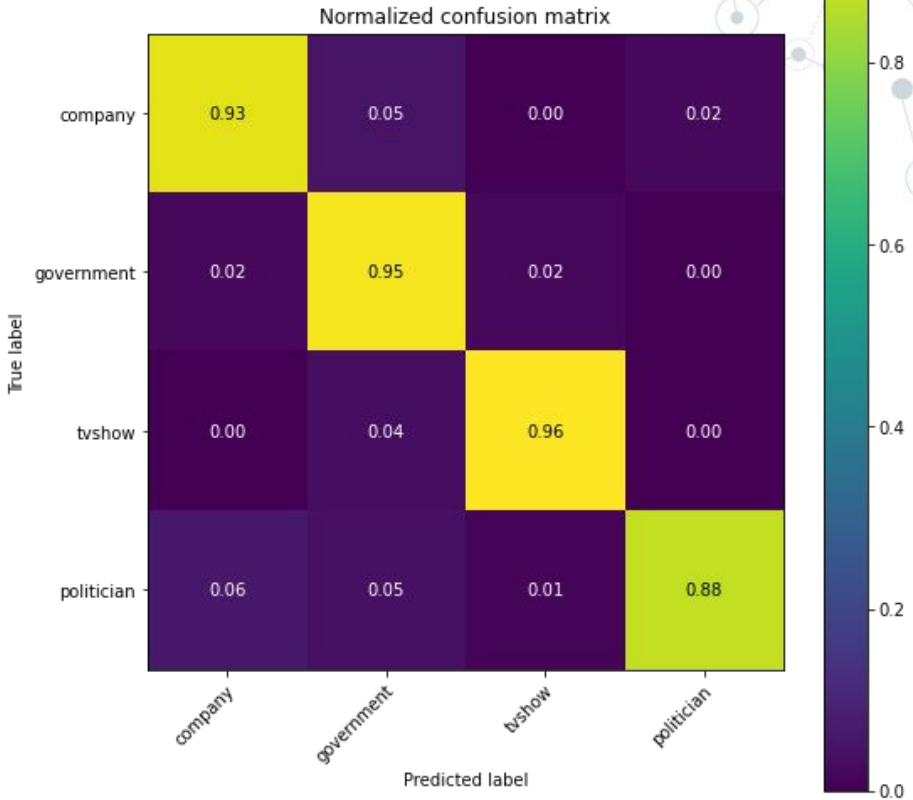
Facebook Large Page-Page Network - Deepwalk (1)

- Deep Walk
  - Random Forest
  - Not Balanced
  - Accuracy = 0.931

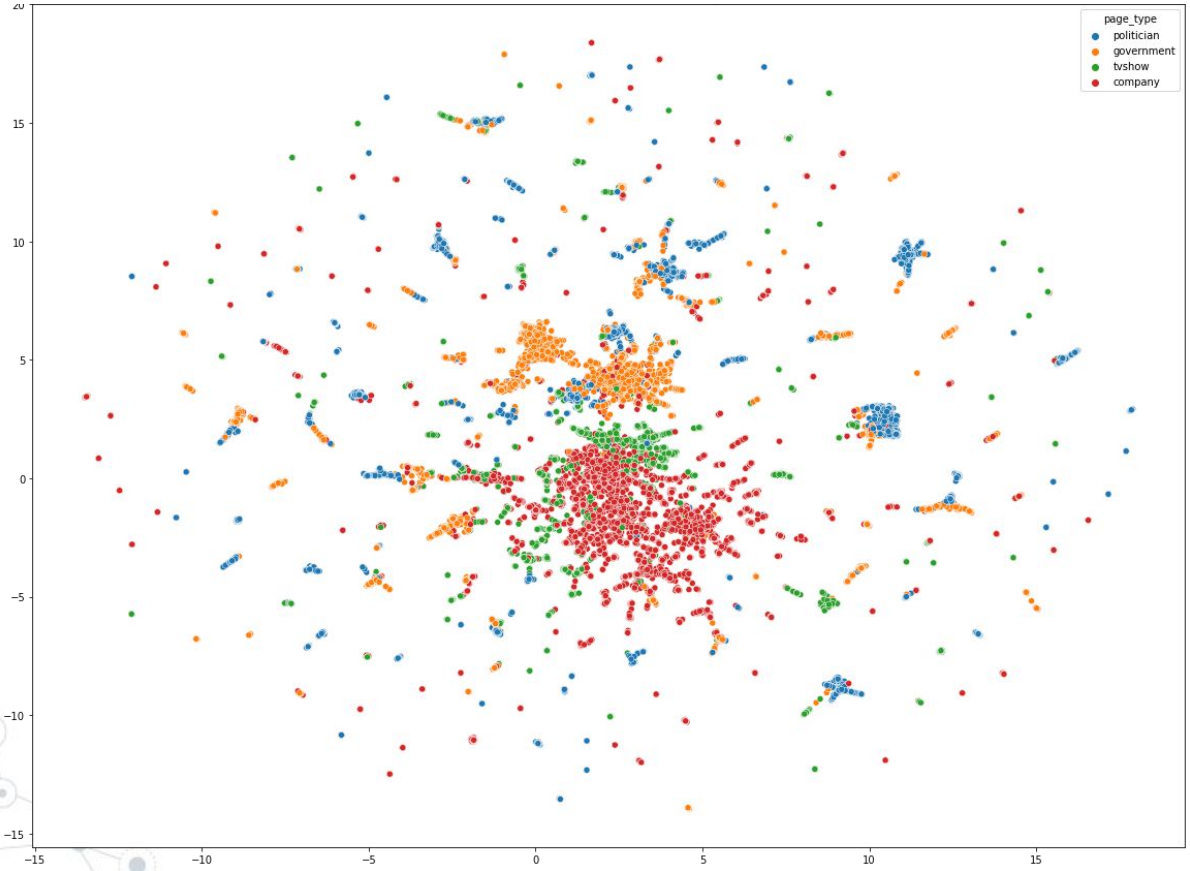


Facebook Large Page-Page Network - Deepwalk (2)

- Deep Walk
  - Random Forest
  - Balanced
  - Accuracy = 0.937

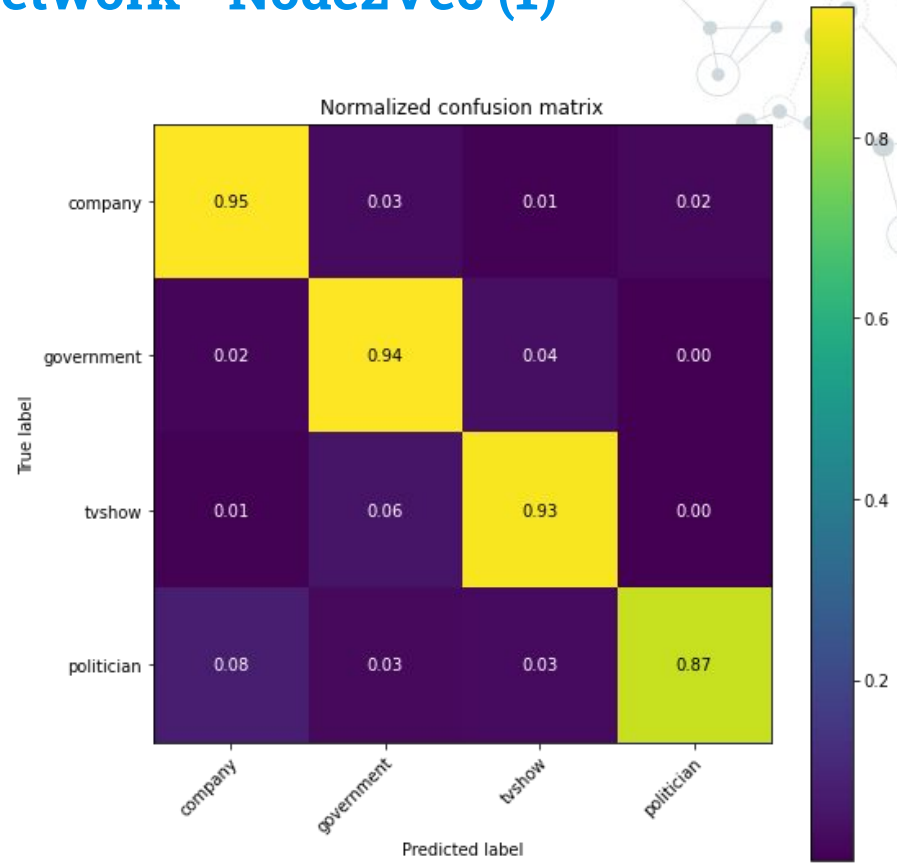


Facebook Large Page-Page Network - Node2Vec



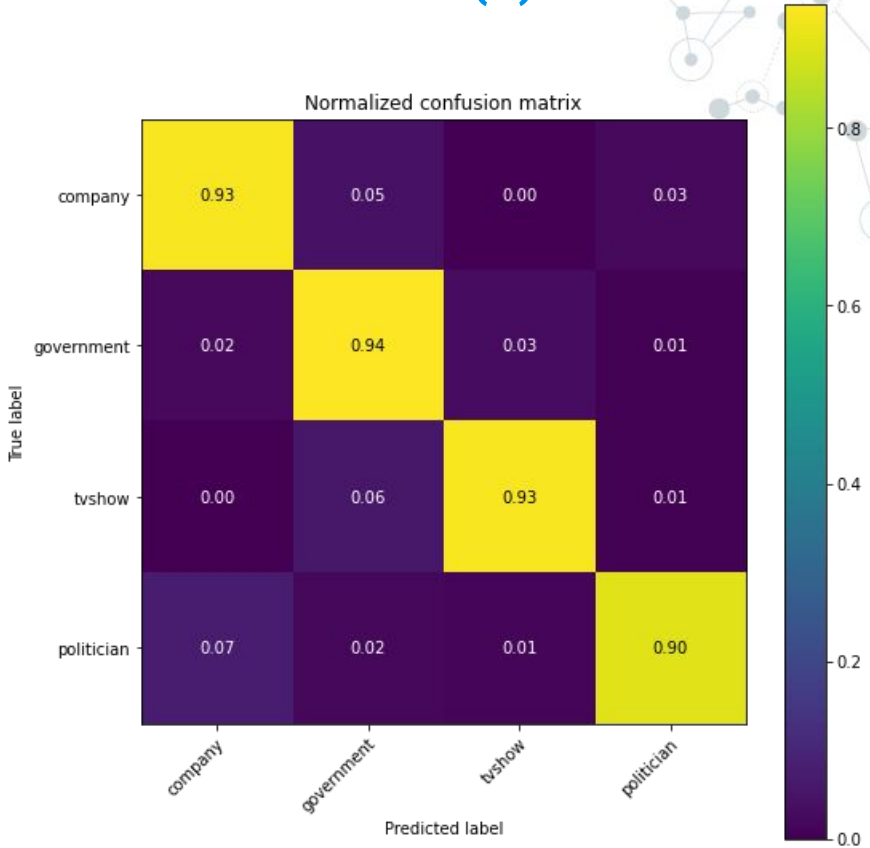
Facebook Large Page-Page Network - Node2Vec (1)

- Node2Vec
  - P = 10
  - Q = 0.1
  - Random Forest
  - Not Balanced
  - Accuracy = 0.931

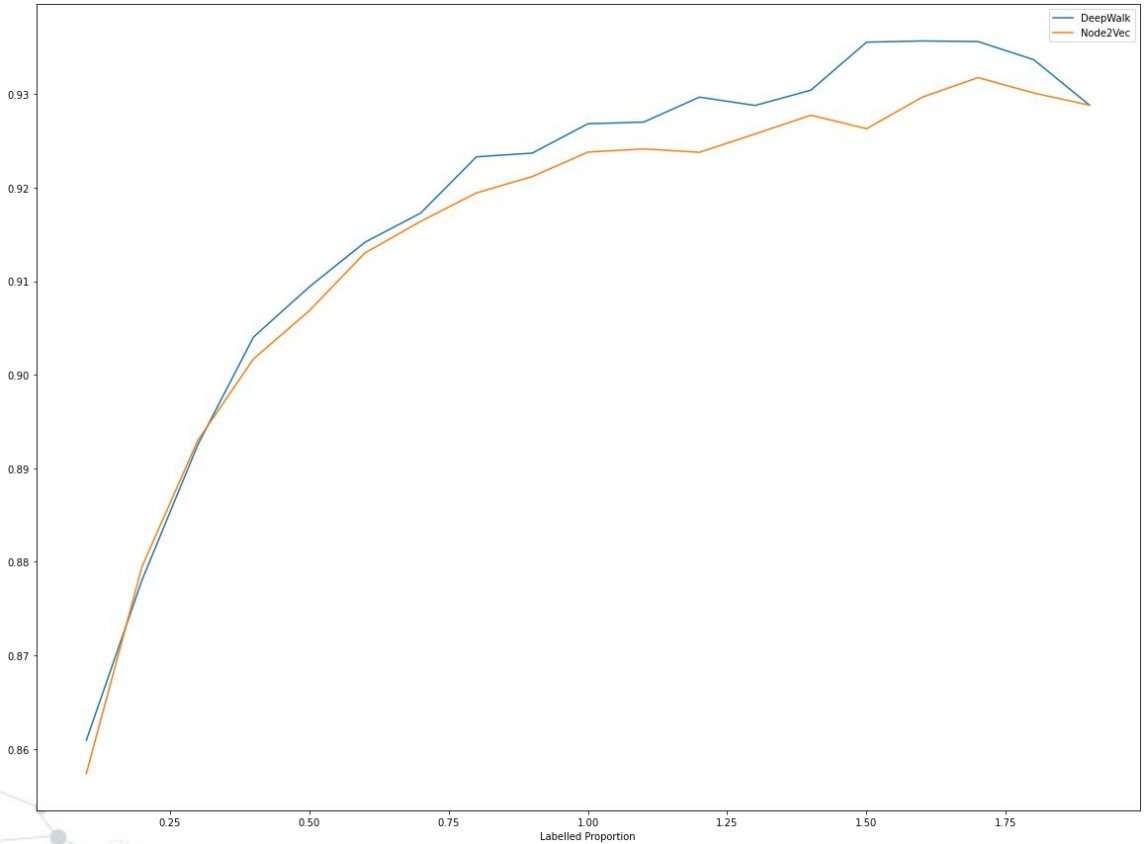


Facebook Large Page-Page Network - Node2Vec (2)

- Node2Vec
  - P = 10
  - Q = 0.1
  - Random Forest
  - Balanced
  - Accuracy = 0.928



Deep Walk vs Node2Vec

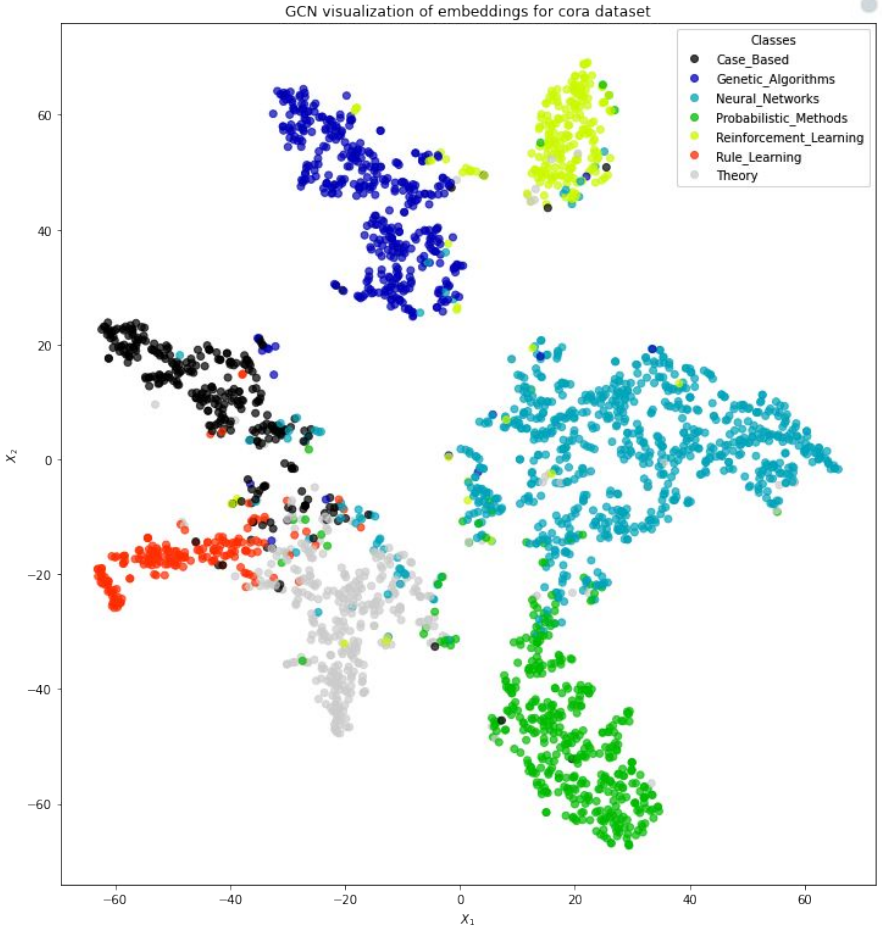


4.3
Cora Dataset

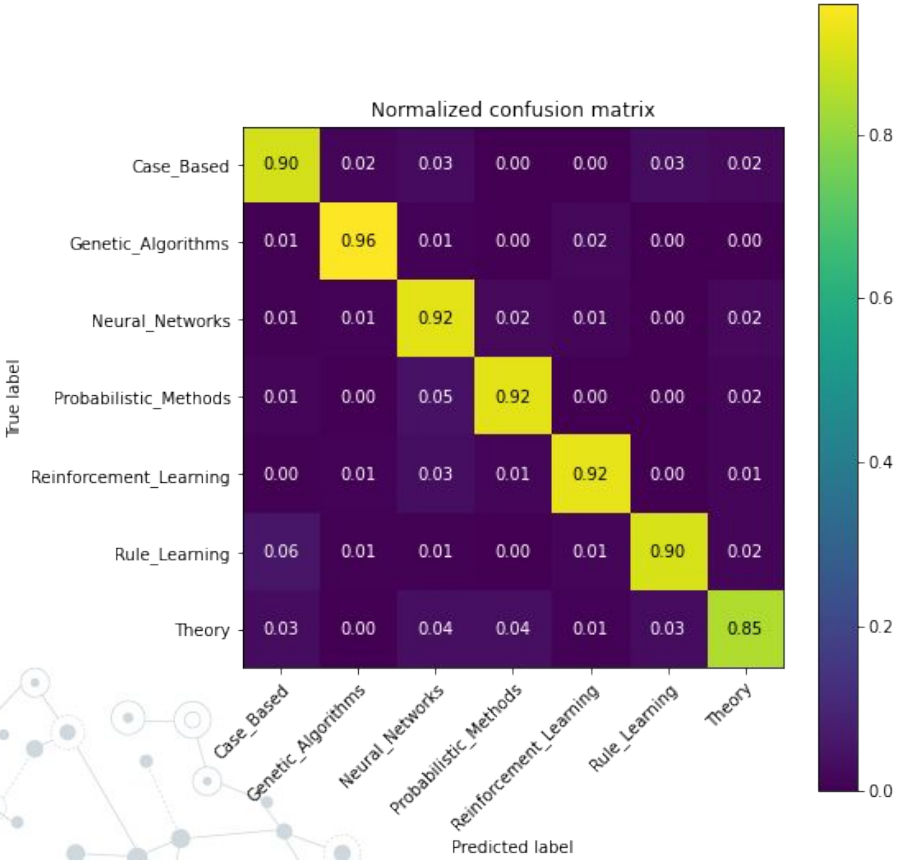
Cora Dataset

- Nodes: 2,780
- Edges: 5,429
- Categories:
  - Neural_Networks
  - Probabilistic_Methods
  - Genetic_Algorithms
  - Theory
  - Case_Based
  - Reinforcement_Learning
  - Rule_Learning

Cora Dataset Classification GCN

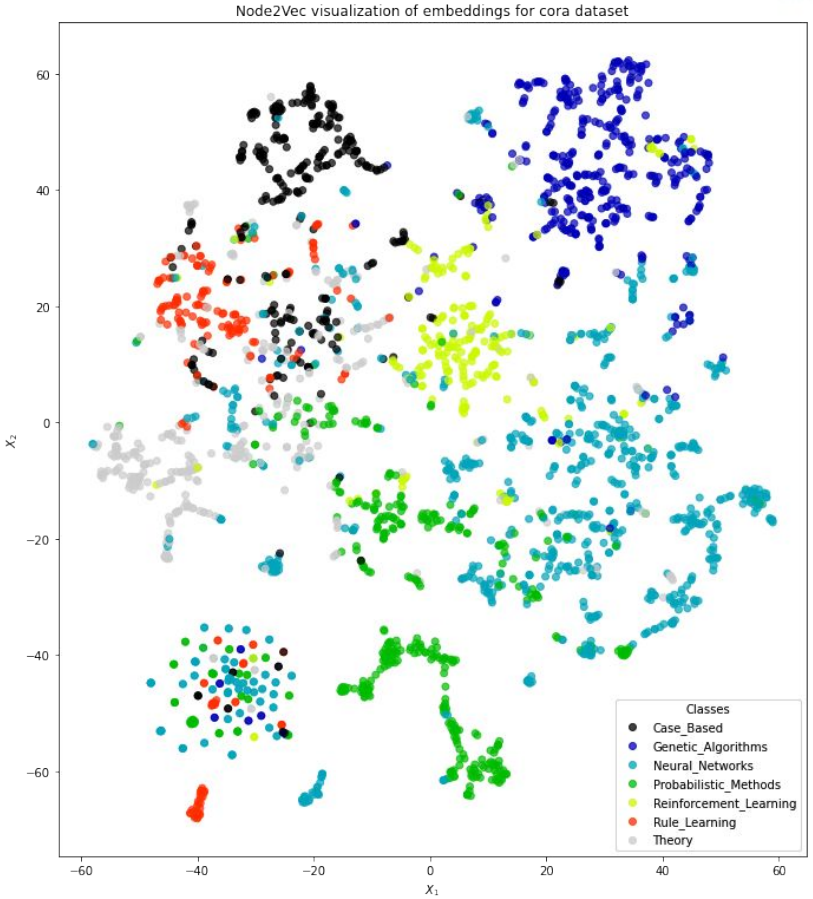


Cora Dataset - Classification - GCN



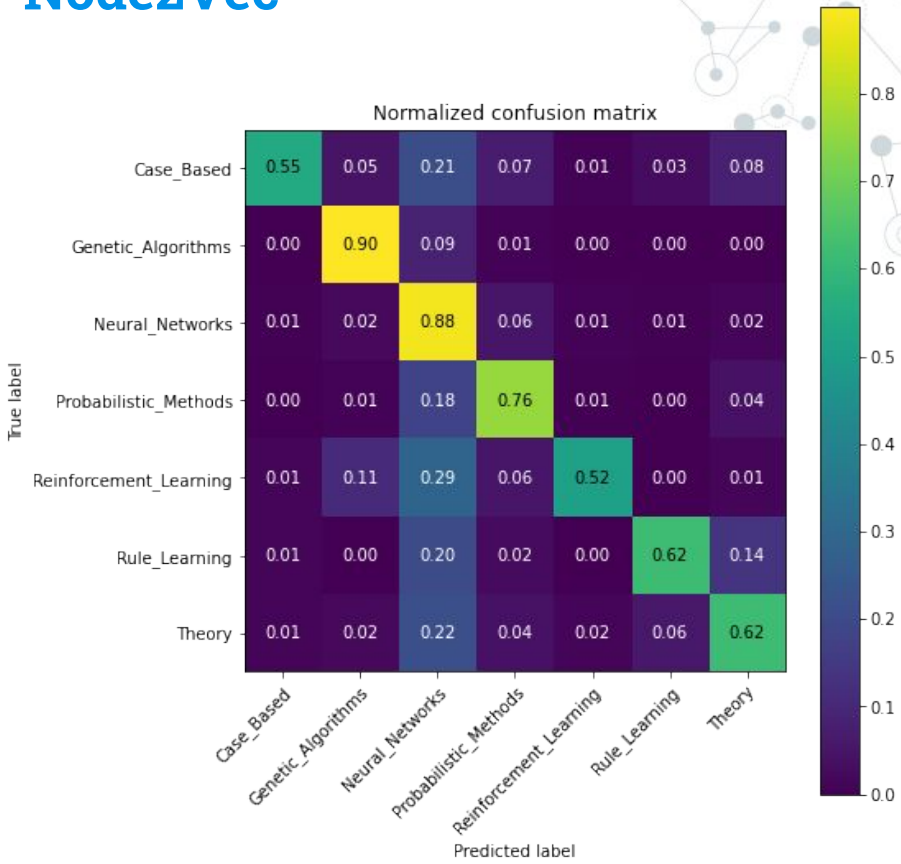
- GCN
  - Accuracy = 0.913

Cora Dataset Classification Node2Vec

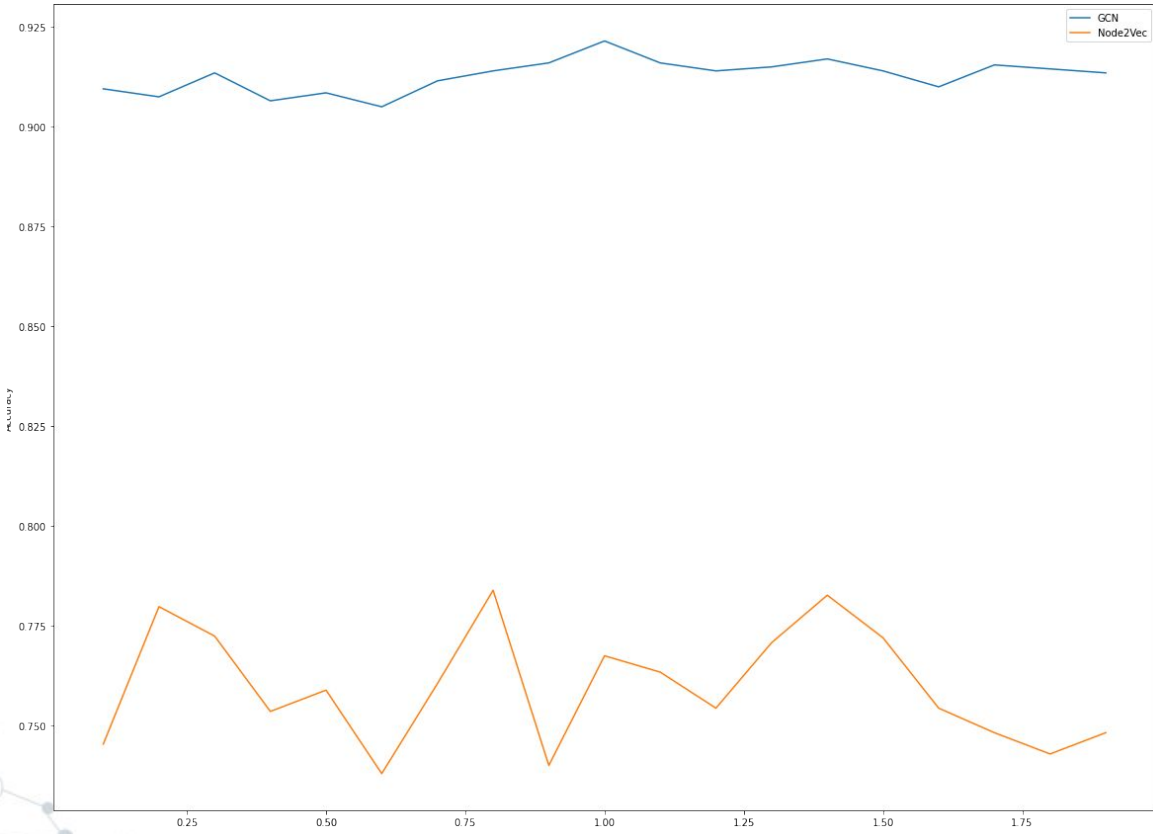


Cora Dataset - Classification - Node2Vec

- Node2Vec
  - P = 0.5
  - Q = 0.25
  - Random Forest
  - Accuracy = 0.748



GCN vs Node2Vec



Conclusion

- Node2Vec is an improvement to DeepWalk. Graph Convolutional Networks is an improvement of Node-2Vec.
- For community detection it is better to use Node2Vec. Ranking improves compared to Deep Walk.
- For classification after comparing the different methods, GCN obtained a more precise accuracy

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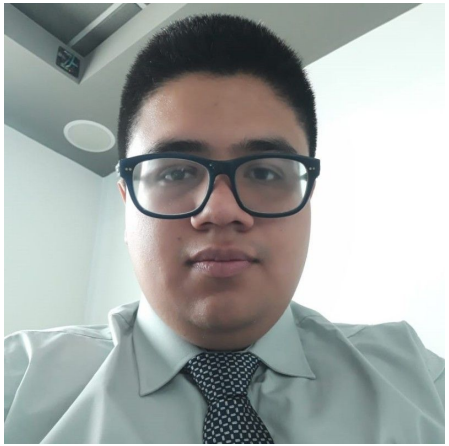
Our Team



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