Graph Mining

Practice Works on Neo4j

ESILV
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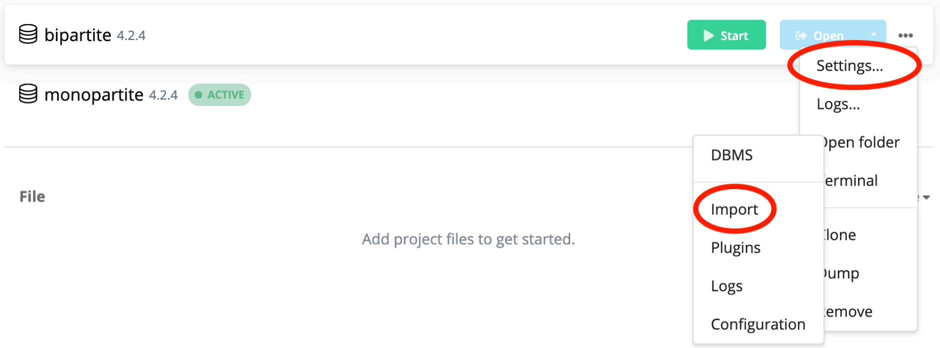
Chapter Contents

Chapter 1
Import the Tourism Circulation dataset

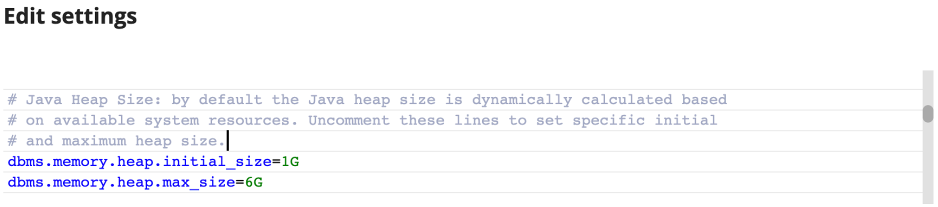
The dataset has been used to study the Circulation of tourists on a geographic territory. You will find the corresponding scientific publication here: `https://link.springer.com/chapter/10.1007%2F978-3-030-62005-9_29`

1.1 Create your database

- Check the *Neo4j desktop version* (if not already installed). Make an update before.
  Tested versions: Neo4j Desktop 1.4.9, with Neo4j 4.3.5;
- Check if your firewall blocks ports 7474 (Neo4j browser) & 7687 (Bolt protocol);
- Create a projet "*Graph Mining*", and create two DBMS "**bi-partite**" and "**mono-partite**".
  If needed, refer to the guide used last year: `https://chewbii.com/neo4j-travaux-pratiques/`
- In order to guarantee good performances, edit on both graphs the "**Settings...**" in order to put sufficient memory:



```
dbms.memory.heap.initial_size=1G
dbms.memory.heap.max_size=6G
```



Edit settings

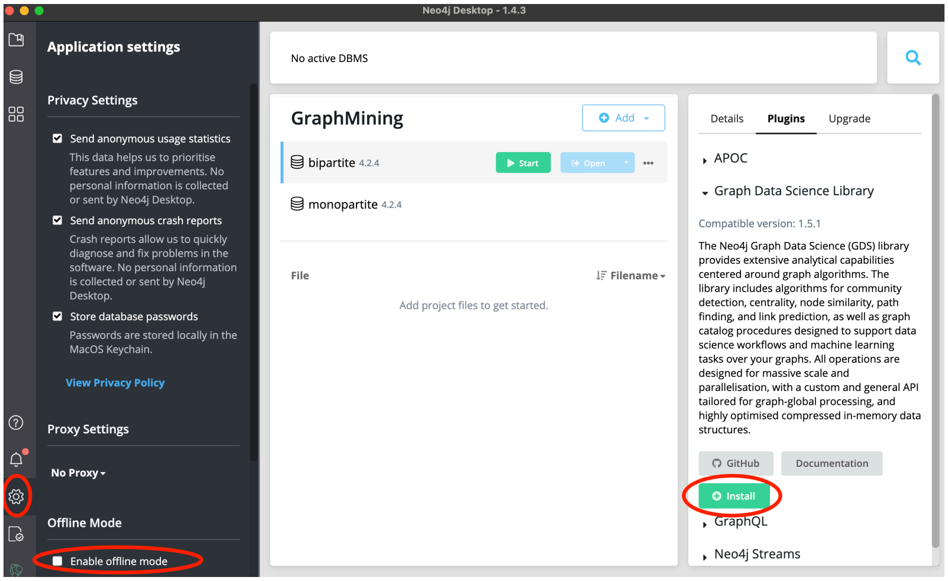
```
# Java Heap Size: by default the Java heap size is dynamically calculated based
# on available system resources. Uncomment these lines to set specific initial
# and maximum heap size.
dbms.memory.heap.initial_size=1G
dbms.memory.heap.max_size=6G
```

  Can be 6G if you want to keep more space for the graph. Becareful, do not exceed the amount of memory *left* on your laptop (OS, browser, apps, services take a lot of memory).

- Now download the two datasets from DVO, unzip the archives, and put the files in the each import folder ("...", "Open Folder", "Import") for "bipartite" and "monopartite" graphs;

1.2 Activate GDS

- If necessary, remove the "*Enable offline mode*" in **Settings** (bottom left of the Desktop - see picture above);
- Click on your database in order to show the *details* bar (right side);
- Click on the *Plugins* tab, then on "Graph Data Science Library";



Privacy Settings

☑ Send anonymous usage statistics
This data helps us to prioritise features and improvements. No personal information is collected or sent by Neo4j Desktop.

☑ Send anonymous crash reports
Crash reports allow us to quickly diagnose and fix problems in the software. No personal information is collected or sent by Neo4j Desktop.

☑ Store database passwords
Passwords are stored locally in the MacOS Keychain.

Proxy Settings

Offline Mode

□ Enable offline mode

Add project files to get started.

Compatible version: 1.5.1

The Neo4j Graph Data Science (GDS) library provides extensive analytical capabilities centered around graph algorithms. The library includes algorithms for community detection, centrality, node similarity, path finding, and link prediction, as well as graph catalog procedures designed to support data science workflows and machine learning tasks over your graphs. All operations are designed for massive scale and parallelisation, with a custom and general API tailored for graph-global processing, and highly optimised compressed in-memory data structures.

- Install the plugin;
- Do it on both graphs;
- If necessary, restart the database in order to take into account the plugin.

1.2.1 Bi-partite Graph

This dataset is an extraction from Tripadvisor reviews where you can find correlations between users (anonymized) and French locations.

- Start the "*bipartite*" database;
- Open the "**bi-partite**" DBMS browser.
  If the button is not clickable, use in your own Web browser: `http://localhost:7474`;
- Create indexes as in the following but *one query at a time only*:

```
CREATE INDEX ON :User(id);
//If you have an old version of Neo4j, replace "ON" by "FOR"

CREATE INDEX FOR :User(country);

CREATE INDEX FOR :Area_4(gid);

CREATE INDEX FOR :Area_4(gid_4);
```

- Import `User` nodes:

```
:auto LOAD CSV WITH HEADERS FROM "file:/users.csv" as l FIELDTERMINATOR "\t"
MERGE (user:User{id:toInteger(l.user_id), country:l.country});
```

- Import `Area_4` nodes:

```
:auto LOAD CSV WITH HEADERS FROM "file:/gadm36_4.csv" as l FIELDTERMINATOR "\t"
CREATE (loc:Area_4{gid:toInteger(l.gid),name:l.nom,
        gid_0:l.gid_0,name_0:l.name_0, gid_1:l.gid_1,name_1:l.name_1, gid_2:l.gid_2,name_2:l.name_2,
        gid_3:l.gid_3,name_3:l.name_3, gid_4:l.gid_4,name_4:l.name_4});
```

Gadm3.6 is a database which stores all information according to administrative areas all around the world. Here are extracted information from France.

  - Area_0: Country
  - Area_1: Region
  - Area_2: Department
  - Area_3: District (*Canton* in French)
  - Area_4: Cities (*Communauté de communes* in French)
  - Area_5: Towns (*villes/villages* in French) - not shown in this file

- Import `Reviews` relationships.
  It can take a while - sometimes several minutes - **do not forget to index nodes and change the heap size!**
  The global file has been split in 10 distinct "reviews" file. Change the file number to import it 10 times.

```
:auto LOAD CSV WITH HEADERS FROM "file:/reviews_0.csv" as l FIELDTERMINATOR "\t"
MERGE (area:Area_4{gid_4:l.gid_to} )
MERGE (user:User{id:toInteger(l.user_id)} )
MERGE (user) -[:review{year:toInteger(l.year),rating:toFloat(l.rating),NB:toInteger(l.NB)}]-> (area);
```

1.2.2 Mono-partite graph

This dataset is a transformation of the bi-partite graph imported previously. Here are the steps already applied:

- Locations are grouped by GADM3.6 at level 4 : **Cities**
- For each couple of reviews from a same user, create a link between the two corresponding cities.
- Group all the links from a given country of origin and year of review to create a weighted relationship.

A Java program has been developped to extract this circulation graph.

- Stop the "*bipartite*" database;
- Start the "*monopartite*" database;
- Open the "**mono-partite_circulation**" DBMS. After downloading the dataset on DVO, unzip the archive, and put the files in the import folder ("...", "Open Folder", "Import"). Then, open the Neo4j browser.
- In order to guarantee good performances, edit the settings in order to put sufficient memory
- Create indexes as in the following but *one query at a time only*:

```
CREATE INDEX ON :Area_4(gid);
CREATE INDEX ON :Area_4(gid_4);
```

- Import Area nodes:

```
:auto LOAD CSV WITH HEADERS FROM "file:/gadm36_4.csv" as l FIELDTERMINATOR "\t"
MERGE (loc:Area_4{gid:toInteger(l.gid),name:l.nom,
        gid_0:l.gid_0,name_0:l.name_0, gid_1:l.gid_1,name_1:l.name_1, gid_2:l.gid_2,name_2:l.name_2,
        gid_3:l.gid_3,name_3:l.name_3, gid_4:l.gid_4,name_4:l.name_4});
```

- Import circulation relationships:

```
:auto LOAD CSV WITH HEADERS FROM "file:/circulationGraph_4.csv" as l FIELDTERMINATOR "\t"
MERGE (from:Area_4{gid:toInteger(l.gid_from)} )
MERGE (to:Area_4{gid:toInteger(l.gid_to)} )
MERGE (from) -[:trip{year:toInteger(l.year),NB:toInteger(l.NB),country:l.country}]-> (to);
```

Done! You can work on the practice work on both graphs.

Chapter 2

Mining Bi-partite Graphs

First, close all graph databases except the "**bi-partite**" graph. Open the browser.

2.1 Similarity

2.1.1 Take the two French users who reviewed the most (sum of NB);

2.1.2 Give their *Jaccard* Similarity (use `WITH` clause to exploit previous result - user 1 and then user 2);

2.1.3 Take the two French users who reviewed the most areas. Give their similarity;

2.1.4 Explain the difference;

2.1.5 For those couples, give the *overlap* and explain the difference with *Jaccard*;

2.1.6 For those couples, give the *Euclidean* and *cosine* similarities, using the NB. Explain the difference (between couples and other similarities);

2.1.7 Idem with ratings (and explanation);

2.1.8 Give the average *jaccard* and *overlap* similarities[1] for **Spanish** where they visited at least 5 places per area (NB >= 5);

2.1.9 Give the one for British, American and Italians. Explain the differences.

2.2 Link Prediction

2.2.1 Give the number of common neighbors between the two French who reviewed the most (seen before);

2.2.2 Get each list of neighbors and check the result;

2.2.3 Give the link prediction on *total neighbors*, *preferential attachment, resource allocations* and *Adamic Adar*;

2.2.4 Explain the differencies;

2.2.5 Give the top 10 shared neighbors between the top 10 spanish reviewers (sum of NB). Give for all similarities (*total neighbors*, *preferential attachment, resource allocations* and *Adamic Adar*) ordered by adamic adar.

2.2.6 Discuss the result by looking at common neighbors.

[1] Euclidean and Cosine must have same vector size which is not always the case.

Chapter 3

Mining Mono-partite Graphs

First, close all graph databases except the “**mono-partite**” graph. Open the browser.

3.1 Cypher Projection

In the following, we need to create several sub-graphs in order to understand various behavior from the users.

3.1.1 Create a Cypher Projection named “French2019” where you extract the graph for the French in 2019 population with NB;

3.1.2 Idem with “French2020”, “British2019”, “British2020”, “US2019”, “US2020”;

3.2 Community Detection

3.2.1 Give the number of triangles per node for French2019 and French2020, in decreasing order;

3.2.2 Idem but grouped by department (Area_2). Discuss the result;

3.2.3 Idem with the *clustering coefficient*. Discuss the result (Infinity and different results);

3.2.4 Extract communities with “*Label Propagation*” on different Cypher projections;

3.2.5 From the previous result, give the list of communities per department. Discuss the result;

3.2.6 Idem with “*Louvain*”;

3.2.7 Group previous result per communityId. Discuss the result;

3.3 Path finding

3.3.1 Give all pairs of shortest paths in Spain2019 based on NB properties. Need to use a Map configuration instead on CypherProjection (with ”nodeQuery” and ”relationshipQuery”);

3.3.2 Extract the Minimum Spanning Tree starting from “Paris 1° arrondissement”;

3.3.3 Extract the **Maximum** Spanning Tree;

3.4 Centrality

3.4.1 Extract *PageRank* centralities from nodes in different various cypher projection. Discuss the order of results (weights are dependant on the graph);

3.4.2 Give the average, min and max PageRank score for corresponding departments. Explain the differences;

3.4.3 Give Degree, Closeness, Betweenness centralies for those graphs and explain differences.