

1. Detecting your first Community Structure

To detect communities, you can use the `cdlib` package. It also contains functions for evaluation and comparison of partitions. For details, check the documentation at <https://cdlib.readthedocs.io/en/latest/>

!!! With google colab, you can install it with `!pip install cdlib`, but, due to a colab bug, you also need to do first:

`!pip uninstall python-louvain` validate with `y`, then `!pip install python-louvain`.

- (a) Using `networkx`, load the airport dataset, provided as a graphml file. (reminder: you can download it in colab with `!wget URL` with `URL` the url of the file.
- (b) Using `cdlib`, detect communities on this network using the louvain method. You have to use the `algorithms.louvain` method.
- (c) Visualize the communities found. In order to interpret them, you should draw each node at its geographical location, with a color per community.

There are several ways to draw a spatial network with colors corresponding to communities, from using Gephi to plotting points on an interactive map using `folium`. Here, I provide a simple code to plot the data as a simple scatter plot

Listing 1: plot on a map

```
import seaborn as sns
import matplotlib.pyplot as plt
x= list(nx.get_node_attributes(g,"lon").values())
y= list(nx.get_node_attributes(g,"lat").values())

coms_dict=coms.to_node_community_map()
hues=list(coms_dict[n][0] for n in g.nodes())

plt.figure(figsize=(12,8))
sns.scatterplot(x=x,y=y,hue=hues,palette=sns.color_palette(
"tab20",len(coms.communities)),s=5)
```

- (d) Vary the resolution parameter and observe changes in the community structure.

2. Comparing Partitions

- (a) The provided airport data also contains information about the country of each airport, which can be interpreted as a *ground truth* partition of the network. Transform this information into a `NodeClustering` object of `cdlib` (`NodeClustering(partition,graph,"GroundTruth")`), with `partition` a list of list of nodes.
- (b) Compute the AMI, NMI, or another similarity score (<https://cdlib.readthedocs.io/en/latest/reference/evaluation.html>) between the community structure and the partition in countries
- (c) By exploring with a for loop the values of the resolution parameter for modularity, find the partition with the highest similarity to the partition in countries.

- (d) Compare visually the results, and try to interpret it. Is the partition in country a meaningful topological partition, i.e., is studying this network by considering that nodes in a same country form a coherent/homogeneous group a good approach? (yes and no, probably...)

3. Going further : Intuitions on the SBM

I propose this exercise using only `networkx` and `cdlib`. You could do much more with SBM using `graph-tool` package (real SBM inference, degree-corrected SBM, Hierarchical SBM, etc.), but it requires a little bit more time to get used to at first, so I recommend it only if you're particularly interested in the topic.

- (a) Compute the block matrix for a reasonable partition of the graph. For a given partition, you need to count the number of edges between and inside each community.
- (b) Using `networkx` `stochastic_block_model` method, generates a graph based on the computed block matrix
- (c) Using the network and node descriptors that you know, compare the properties of this generated graph with the properties of your original graph (and with a simple ER or configuration model). How is it different? How is it similar? Think about clustering coefficient, average distance, distribution of node centralities, degree distribution, etc.
- (d) How do these properties change when you increase/decrease the number of blocks?