problem_4_3

November 22, 2021

1 Problem 4-3

Group members: 1) Shuhan Xiao (Uni-id: kg410 Matrikelnr.: 3160697), 2) Klaus Kades (Uni-id: fw448 Matrikelnr.: 3408463), 3) Lucas-Raphael Müller (Uni-id: al413 Matrikelnr.: 3205638), 4) Melanie Schellenberg (Uni-id: qh400 Matrikelnr.: 3146390)

1.1 Installation

is done via conda as follows

```
conda env create -f environment.yaml
conda activate complex_network
jupyter lab # opens jupyter lab in a browser window
```

[120]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import igraph
import scipy.optimize
import powerlaw

from pathlib import Path

%config InlineBackend.figure_format='retina'
```

[3]:

```
# paths
path_data = Path("/Users/lucasmueller/Documents/Projects/complex_network/
 ↪facebook-links.txt")
```

1.2 Preperation

[4]:

```
df = pd.read_csv(path_data, sep="\t", names=["source", "target", "timestamp"])
df = df[["source", "target"]]

# make graph pythonic
df = df - 1
```

[5]:

```
df
```

[5]:
```
         source  target
0             0       1
1             0       2
2             0       3
3             0       4
4             0       5
…           …     …
1545681   21168   12887
1545682   21168   18659
1545683   48808   24064
1545684   48808   29257
1545685   55903   11087

[1545686 rows x 2 columns]
```

[6]:
```python
# add an edge which neglects the order (by sorting it)
df['edge'] = df.apply(lambda r: tuple(sorted((r.source, r.target))), axis=1)

# drop duplicates
df = df.drop_duplicates('edge')
df
```

[6]:
```
         source  target            edge
0             0       1          (0, 1)
1             0       2          (0, 2)
2             0       3          (0, 3)
3             0       4          (0, 4)
4             0       5          (0, 5)
…           …     …             …
1545556   31970   13389  (13389, 31970)
1545643   18750   19388  (18750, 19388)
1545650   18750   27761  (18750, 27761)
1545654   18750   17545  (17545, 18750)
1545668   27324   49527  (27324, 49527)

[817090 rows x 3 columns]
```

[7]:
```python
g = igraph.Graph()

g.add_vertices(list(set(df.source.to_list()) | set(df.target.to_list())))
g.add_edges(df.edge.to_list())
```

1.3 Tasks

[8]:
```python
# diameter
g.diameter()
```

[8]:
```
15
```

[17]:
```python
# degree
arg_degree = np.argmax(g.vs.degree())

print(f"highest degree: {g.vs.degree()[arg_degree]} (ID: {arg_degree + 1})")
```

```
highest degree: 1098 (ID: 2332)
```

[65]:
```python
# number of triangles
len(g.cliques(3, 3))
```

```
3501542
```

[134]:
```python
# global clustering coefficient
print(f"{g.transitivity_undirected():.2f}")
```

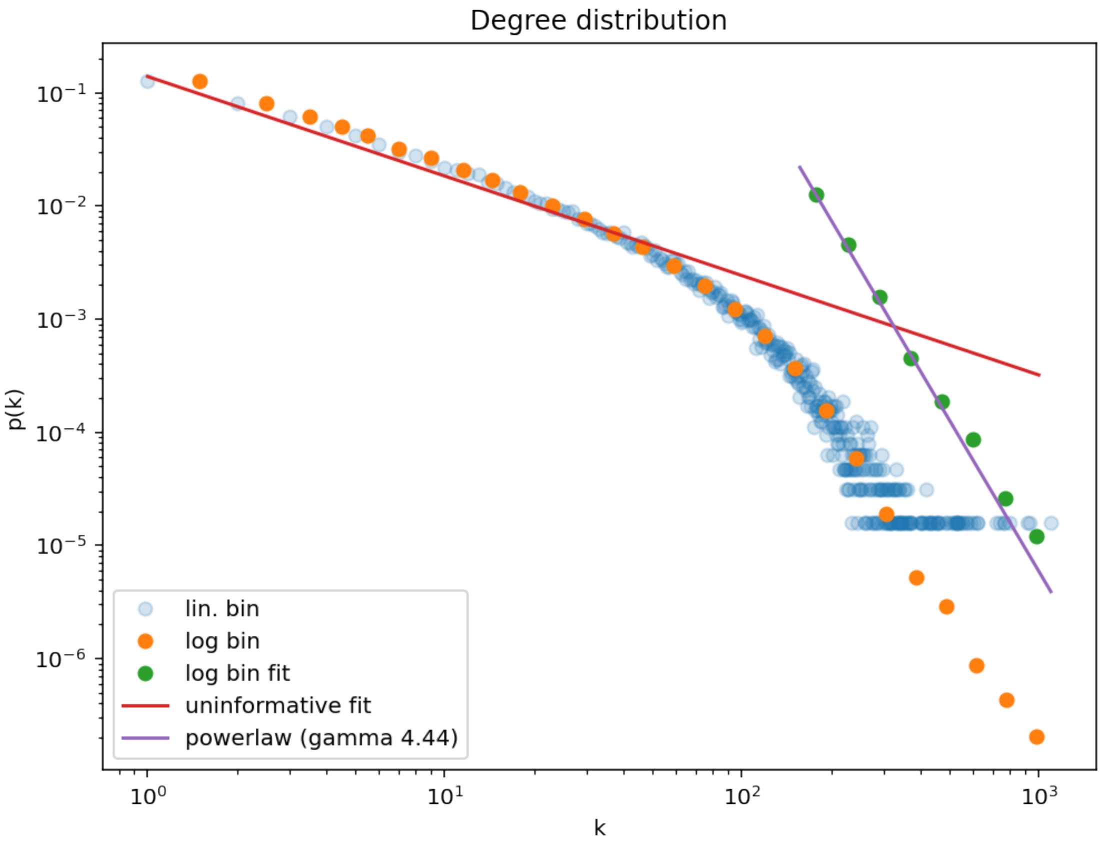
```
0.15
```

[135]:
```python
# power-law exponent of degree distribution
def model(k, gamma, c):
    return c * k ** (-gamma)

p_opt, p_cov = scipy.optimize.curve_fit(model, deg[:, 0], deg[:, -1] / len(g.
 ↪vs))
```

[136]:
```python
# actual vs fitted degree distribution
deg = list(g.degree_distribution().bins())
deg = np.array(deg)#[:, [0, -1]]

# powerlaw
fit = powerlaw.Fit(g.vs.degree())

# model function
k = np.linspace(1, 1000, 1000)
m = model(k, *p_opt)
```

```
Calculating best minimal value for power law fit
xmin progress: 99%
```

[137]:
```python
plt.figure(figsize=(8, 6))

plt.plot(deg[:, 0], deg[:, -1] / len(g.vs), 'o', alpha=0.2)  # actual data
powerlaw.plot_pdf(g.vs.degree(), marker='o', linestyle='none')
fit.plot_pdf(marker='o', linestyle='none')
plt.plot(k, m)  # uninformative fit
fit.power_law.plot_pdf()

plt.xscale('log')
plt.yscale('log')

plt.xlabel('k')
plt.ylabel('p(k)')

plt.legend(["lin. bin", "log bin", "log bin fit", "uninformative fit",␣
 ↪f"powerlaw (gamma {fit.alpha:.2f})"])
plt.title("Degree distribution")

plt.show()
```



```
[ ]:
```