01-Network-Analysis

October 16, 2017

```
In [50]: %%capture
         !rm -rf shakespeare_data/plays_xml
         !unzip -P rtad shakespeare_data/plays.zip -d shakespeare_data/plays_xml
```

```
In [51]: %%capture
         import numpy as np
         import networkx as nx
         from lxml import etree
         import itertools
         from datascience import *
         import matplotlib.pyplot as plt
         %matplotlib inline
```

1 Social Network Analysis: NetworkX

Mark Algee-Hewitt looks at thousands of plays across centuries. But as we've learned so far, to do this we first have to figure out how to calculate the metrics we're interested in for a single text. Let's take a look at a single play. Luckily, there are databases that exists that have already annotated a lot of plays in a markup language called XML. Especially well researched corpora have extensive metadata. We'll look at the Shakespeare corpus with data obtained from https://www.playshakespeare.com/ .

We'll start by looking at *Othello*.

```
In [52]: with open("shakespeare_data/plays_xml/othello_ps_v3.xml") as f:
             othello_xml = etree.fromstring(f.read().encode())
```

If we're trying to build a network we need two things: 1) nodes and 2) edges. For Algee-Hewitt, and for us today, that means we need to know the characters in *Othello*, and with whom they communicate. We'd also like to know how often that specific interaction occurs.

We can get all elements of the XML tree by `iterating` over all the nodes:

```
In [53]: all_elements = list(othello_xml.iter())
         all_elements
```

```
Out[53]: [<Element play at 0x7f5a37b0dbc8>,
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...]
```

That's a lot of information! Let's grab out all of the speakers. All the `speaker` elements will have a `text` attribute that has their actual name, or abbreviation of their name.

```
In [54]: [e.text for e in all_elements if e.tag == "speaker"]

Out[54]: ['ROD.',
          'IAGO.',
          'ROD.',
          'IAGO.',
```

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                    ...]
```

To get a unique list we'll use set:

```
In [55]: set([e.text for e in all_elements if e.tag == "speaker"])

Out[55]: {'1. GENT.',
          '1. MESS.',
          '1. MUS.',
          '1. SEN.',
          '2. GENT.',
          '2. MESS.',
```

```
        '2. SEN.',
        '3. GENT.',
        'ALL.',
        'BIAN.',
        'BRA.',
        'CAS.',
        'CLO.',
        'DES.',
        'DUKE',
        'DUKE.',
        'EMIL.',
        'GENTLEMEN.',
        'GRA.',
        'HER.',
        'IAGO',
        'IAGO.',
        'LOD.',
        'MON.',
        'OFF.',
        'OTH.',
        'ROD.',
        'SAIL.'}
```

Great start! In Network Analysis there are two fundamental principles. A ***node*** is an entity, it can have relationships with other entities. In literature, this is often a character, but it could be a Twitter user, organization, geographic location, or even words!

We may be interested in a node's properties. If it's a character, we may want to know how often they speak, age, etc. We can add this to the network as further layers.

The second concept is an ***edge***. An edge connects nodes. We're foremost interested in the volume of connections between nodes. For literature, this would be the number of times two characters interact.

As we learned from Moretti and our readings for today, this is a very difficult task for most texts. Where does on character's speech end and another's begin? Luckily, in plays this is slightly easier to identify (though still not perfectly clear).

For Shakespeare, we'll settle for them being present in the same *scene*. If they're in the same scene together, we'll increase our measure of their interaction.

Thus for each character we want to know how many lines the speak in the entire play, along with which scenes they appear in. We can then collate this wil the other characters.

The `get_cast_dict` function below will parse the XML data and extract this information.

```python
In [56]: def get_cast_dict(all_elements):
             '''
             returns a dictionary with the total number of lines and scenes a character appear
             '''

             cast_dict = {}

             # first get a unique set of all characters appearing in the play
```

```python
        for c in set([e.text for e in all_elements if e.tag == "speaker"]):
            cast_dict[c] = {"num_lines": 0,
                            "scenes": []}

        # extract all scene elements from the xml
        scenes = [e for e in all_elements if e.tag == "scene"]
        acts = [e for e in all_elements if e.tag == "act"]
        # acts = [e.find("acttitle").text for e in all_elements if e.tag == "act"]

        for a in acts:

            # get title of acts
            act_title = a.find("acttitle").text

            # get scene elements
            scenes = [e for e in a if e.tag == "scene"]
            # iterate through each scene
            for sc in scenes:

                # grab all the speeches in the scene
                speeches = [s for s in sc.getchildren() if s.tag == "speech"]

                # iterate through speeches
                for s in speeches:

                    # increment number of lines for the speaker
                    cast_dict[s.find("speaker").text]["num_lines"] += len(s.findall("line"

                # find all the speaker for each speech
                speakers = [s.find("speaker").text for s in speeches]

                # add the title of the scene for each speaker appearing in the scene
                for s in set(speakers):
                    cast_dict[s]["scenes"].append(act_title + " " + sc.find("scenetitle")

            # reassign scenes to only a unique set
            for c in cast_dict.keys():
                cast_dict[c]["scenes"] = list(set(cast_dict[c]["scenes"]))

        return cast_dict

In [57]: cast_dict = get_cast_dict(all_elements)
         cast_dict

Out[57]: {'1. GENT.': {'num_lines': 3, 'scenes': ['Act 2 Scene 1']},
          '1. MESS.': {'num_lines': 9, 'scenes': ['Act 1 Scene 3']},
          '1. MUS.': {'num_lines': 5, 'scenes': ['Act 3 Scene 1']},
          '1. SEN.': {'num_lines': 26, 'scenes': ['Act 1 Scene 3']},
```

```
'2. GENT.': {'num_lines': 14, 'scenes': ['Act 2 Scene 1']},
'2. MESS.': {'num_lines': 2, 'scenes': ['Act 2 Scene 1']},
'2. SEN.': {'num_lines': 5, 'scenes': ['Act 1 Scene 3']},
'3. GENT.': {'num_lines': 17, 'scenes': ['Act 2 Scene 1']},
'ALL.': {'num_lines': 4,
 'scenes': ['Act 2 Scene 3', 'Act 1 Scene 3', 'Act 5 Scene 2']},
'BIAN.': {'num_lines': 26,
 'scenes': ['Act 5 Scene 1', 'Act 4 Scene 1', 'Act 3 Scene 4']},
'BRA.': {'num_lines': 139,
 'scenes': ['Act 1 Scene 2', 'Act 1 Scene 3', 'Act 1 Scene 1']},
'CAS.': {'num_lines': 224,
 'scenes': ['Act 5 Scene 1',
  'Act 2 Scene 3',
  'Act 3 Scene 3',
  'Act 5 Scene 2',
  'Act 3 Scene 1',
  'Act 1 Scene 2',
  'Act 4 Scene 1',
  'Act 2 Scene 1',
  'Act 3 Scene 4']},
'CLO.': {'num_lines': 14, 'scenes': ['Act 3 Scene 1', 'Act 3 Scene 4']},
'DES.': {'num_lines': 353,
 'scenes': ['Act 4 Scene 2',
  'Act 3 Scene 3',
  'Act 1 Scene 3',
  'Act 5 Scene 2',
  'Act 4 Scene 3',
  'Act 2 Scene 3',
  'Act 4 Scene 1',
  'Act 2 Scene 1',
  'Act 3 Scene 4']},
'DUKE': {'num_lines': 1, 'scenes': ['Act 1 Scene 3']},
'DUKE.': {'num_lines': 64, 'scenes': ['Act 1 Scene 3']},
'EMIL.': {'num_lines': 228,
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  'Act 5 Scene 1',
  'Act 3 Scene 3',
  'Act 5 Scene 2',
  'Act 3 Scene 1',
  'Act 4 Scene 3',
  'Act 2 Scene 1',
  'Act 3 Scene 4']},
'GENTLEMEN.': {'num_lines': 1, 'scenes': ['Act 3 Scene 2']},
'GRA.': {'num_lines': 26, 'scenes': ['Act 5 Scene 1', 'Act 5 Scene 2']},
'HER.': {'num_lines': 1, 'scenes': ['Act 2 Scene 2']},
'IAGO': {'num_lines': 14, 'scenes': ['Act 5 Scene 1', 'Act 2 Scene 3']},
'IAGO.': {'num_lines': 867,
 'scenes': ['Act 4 Scene 2',
```

```
                          'Act 5 Scene 1',
                          'Act 1 Scene 1',
                          'Act 2 Scene 3',
                          'Act 3 Scene 3',
                          'Act 1 Scene 3',
                          'Act 5 Scene 2',
                          'Act 3 Scene 2',
                          'Act 3 Scene 1',
                          'Act 1 Scene 2',
                          'Act 4 Scene 1',
                          'Act 2 Scene 1',
                          'Act 3 Scene 4']},
                 'LOD.': {'num_lines': 76,
                  'scenes': ['Act 5 Scene 1',
                          'Act 4 Scene 1',
                          'Act 5 Scene 2',
                          'Act 4 Scene 3']},
                 'MON.': {'num_lines': 58,
                  'scenes': ['Act 2 Scene 3', 'Act 2 Scene 1', 'Act 5 Scene 2']},
                 'OFF.': {'num_lines': 5, 'scenes': ['Act 1 Scene 2', 'Act 1 Scene 3']},
                 'OTH.': {'num_lines': 867,
                  'scenes': ['Act 4 Scene 2',
                          'Act 1 Scene 2',
                          'Act 5 Scene 1',
                          'Act 3 Scene 3',
                          'Act 5 Scene 2',
                          'Act 3 Scene 2',
                          'Act 2 Scene 1',
                          'Act 4 Scene 3',
                          'Act 2 Scene 3',
                          'Act 4 Scene 1',
                          'Act 1 Scene 3',
                          'Act 3 Scene 4']},
                 'ROD.': {'num_lines': 87,
                  'scenes': ['Act 4 Scene 2',
                          'Act 1 Scene 2',
                          'Act 5 Scene 1',
                          'Act 1 Scene 1',
                          'Act 1 Scene 3',
                          'Act 2 Scene 3',
                          'Act 2 Scene 1']},
                 'SAIL.': {'num_lines': 4, 'scenes': ['Act 1 Scene 3']}}
```

That's all we need to make a basic network and do some analysis! We have all the character names and the scenes in which they appear. We can collate some of this information to find out in which scenes certain characters appear together. This will happen in our make_graph function.

The NetworkX Python library will parse this dictionary for us to make a graph object. Let's write a function:

```
In [58]: def make_graph(c_dict):
             '''
             This function accepts a dictionary with number of lines and scenes to create a
             NetworkX graph object
             '''
             # setup graph object
             G = nx.Graph()

             # add nodes with attributes of number of lines and scenes
             for c in c_dict.keys():
                 if c_dict[c]["num_lines"] > 0:
                     G.add_node(
                         c,
                         number_of_lines=c_dict[c]["num_lines"],
                         scenes=c_dict[c]["scenes"]
                     )

             # make edges by iterating over all combinations of nodes
             for (node1, data1), (node2, data2) in itertools.combinations(G.nodes(data=True), 

                 # count scenes together by getting union of their sets
                 scenes_together = len(set(data1['scenes']) & set(data2['scenes']))

                 if scenes_together:
                     # add more weight for more scenes together
                     G.add_edge(node1, node2, weight=scenes_together)

             return G

In [59]: G = make_graph(cast_dict)
```

We can graph this using `matplotlib`:

```
In [60]: # nodes should be sized by number of lines
         node_size = [data['number_of_lines'] for __, data in G.nodes(data=True)]
         node_color = 'blue'

         plt.figure(figsize=(13,8))  # make the figure size a little larger
         plt.axis('off')  # remove the axis, which isn't meaningful in this case
         plt.title("Othello's Social Network", fontsize=20)

         # The 'k' argument determines how spaced out the nodes will be from
         # one another on the graph.
         pos = nx.spring_layout(G, k=0.5)

         nx.draw_networkx(
             G,
             pos=pos,
```

```
            node_size=node_size,
            node_color=node_color,
            edge_color='gray',   # change edge color
            alpha=0.3,   # make nodes more transparent to make labels clearer
            font_size=14,
        )
```

Othello's Social Network

Our graph, G, is a powerful object. We can calculate many of the standard network analysis statistics. There are various measures of centrality, many of which were referenced in the reading.

```
In [61]: network_tab = Table()
         network_tab.append_column(label="Characters", values=[c for c in sorted(cast_dict.keys
         network_tab.show()
```

```
<IPython.core.display.HTML object>
```

Wikipedia defines "degree centrality": >Historically first and conceptually simplest is degree centrality, which is defined as the number of links incident upon a node (i.e., the number of ties that a node has).

```
In [62]: dc = [x[1] for x in sorted(nx.degree_centrality(G).items(), key=lambda x: x[0])]
         network_tab.append_column(label="Degree Centrality", values=dc)
         network_tab.show()
```

```
<IPython.core.display.HTML object>
```

Wikipedia defines "betweeness centrality":

> Betweenness is a centrality measure of a vertex within a graph (there is also edge be-
> tweenness, which is not discussed here). Betweenness centrality quantifies the number
> of times a node acts as a bridge along the shortest path between two other nodes.

```
In [63]: bc = [x[1] for x in sorted(nx.betweenness_centrality(G).items(), key=lambda x: x[0])]
         network_tab.append_column(label="Betweenness Centrality", values=bc)
         network_tab.show()
```

```
<IPython.core.display.HTML object>
```

Wikipedia defines "eigenvector centrality": > Eigenvector centrality (also called eigencentral-
ity) is a measure of the influence of a node in a network. It assigns relative scores to all nodes in
the network based on the concept that connections to high-scoring nodes contribute more to the
score of the node in question than equal connections to low-scoring nodes.

$$x_v = \frac{1}{\lambda} \sum_{t \in M(v)} x_t = \frac{1}{\lambda} \sum_{t \in G} a_{v,t} x_t$$

```
In [64]: ec = [x[1] for x in sorted(nx.eigenvector_centrality(G).items(), key=lambda x: x[0])]
         network_tab.append_column(label="Eigenvector Centrality", values=ec)
         network_tab.show()
```

```
<IPython.core.display.HTML object>
```

2   Challenge

What is the overlap ((rank) correlation) between the three measurements presented above? What
does that mean for the play?

3   Bonus: Making a prettier graph

matplotlib isn't always the most beautiful option. A popular way of visualizing networks is by
using Javascript's D3 library. Luckily, networkx allows us to export the network information to
JSON:

```
In [65]: from networkx.readwrite import json_graph
         import json

         d3_data = json_graph.node_link_data(G)
         d3_data
```

```
Out[65]: {'directed': False,
          'graph': {},
          'links': [{'source': 0, 'target': 1, 'weight': 3},
           {'source': 0, 'target': 2, 'weight': 3},
```

```
{'source': 0, 'target': 4, 'weight': 1},
{'source': 0, 'target': 5, 'weight': 2},
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 {'id': 'DES.',
  'number_of_lines': 353,
  'scenes': ['Act 4 Scene 2',
   'Act 3 Scene 3',
   'Act 1 Scene 3',
   'Act 5 Scene 2',
   'Act 4 Scene 3',
   'Act 2 Scene 3',
   'Act 4 Scene 1',
   'Act 2 Scene 1',
```

```
      'Act 3 Scene 4']},
 {'id': 'CAS.',
  'number_of_lines': 224,
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   'Act 2 Scene 3',
   'Act 3 Scene 3',
   'Act 5 Scene 2',
   'Act 3 Scene 1',
   'Act 1 Scene 2',
   'Act 4 Scene 1',
   'Act 2 Scene 1',
   'Act 3 Scene 4']},
 {'id': 'DUKE.', 'number_of_lines': 64, 'scenes': ['Act 1 Scene 3']},
 {'id': '3. GENT.', 'number_of_lines': 17, 'scenes': ['Act 2 Scene 1']},
 {'id': 'EMIL.',
  'number_of_lines': 228,
  'scenes': ['Act 4 Scene 2',
   'Act 5 Scene 1',
   'Act 3 Scene 3',
   'Act 5 Scene 2',
   'Act 3 Scene 1',
   'Act 4 Scene 3',
   'Act 2 Scene 1',
   'Act 3 Scene 4']},
 {'id': '2. MESS.', 'number_of_lines': 2, 'scenes': ['Act 2 Scene 1']},
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   'Act 4 Scene 1',
   'Act 5 Scene 2',
   'Act 4 Scene 3']},
 {'id': 'CLO.',
  'number_of_lines': 14,
  'scenes': ['Act 3 Scene 1', 'Act 3 Scene 4']},
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   'Act 5 Scene 1',
   'Act 1 Scene 1',
   'Act 2 Scene 3',
   'Act 3 Scene 3',
   'Act 1 Scene 3',
   'Act 5 Scene 2',
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   'Act 2 Scene 1',
```

```
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  'number_of_lines': 26,
  'scenes': ['Act 5 Scene 1', 'Act 5 Scene 2']},
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 {'id': 'OTH.',
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   'Act 1 Scene 2',
   'Act 5 Scene 1',
   'Act 3 Scene 3',
   'Act 5 Scene 2',
   'Act 3 Scene 2',
   'Act 2 Scene 1',
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   'Act 1 Scene 3',
   'Act 3 Scene 4']},
 {'id': 'ALL.',
  'number_of_lines': 4,
  'scenes': ['Act 2 Scene 3', 'Act 1 Scene 3', 'Act 5 Scene 2']},
 {'id': 'HER.', 'number_of_lines': 1, 'scenes': ['Act 2 Scene 2']},
 {'id': 'ROD.',
  'number_of_lines': 87,
  'scenes': ['Act 4 Scene 2',
   'Act 1 Scene 2',
   'Act 5 Scene 1',
   'Act 1 Scene 1',
   'Act 1 Scene 3',
   'Act 2 Scene 3',
   'Act 2 Scene 1']},
 {'id': 'OFF.',
  'number_of_lines': 5,
  'scenes': ['Act 1 Scene 2', 'Act 1 Scene 3']},
 {'id': '1. MESS.', 'number_of_lines': 9, 'scenes': ['Act 1 Scene 3']},
 {'id': '1. MUS.', 'number_of_lines': 5, 'scenes': ['Act 3 Scene 1']},
 {'id': '1. SEN.', 'number_of_lines': 26, 'scenes': ['Act 1 Scene 3']},
 {'id': '2. SEN.', 'number_of_lines': 5, 'scenes': ['Act 1 Scene 3']},
```

```
                 {'id': '2. GENT.', 'number_of_lines': 14, 'scenes': ['Act 2 Scene 1']},
                 {'id': 'BRA.',
                  'number_of_lines': 139,
                  'scenes': ['Act 1 Scene 2', 'Act 1 Scene 3', 'Act 1 Scene 1']}]}
```

We can then add this to a D3 template:

```
In [66]: import re

         with open('network.html', 'r') as f:
             net_html = f.read()

         pattern = re.compile(r'(<script type="application/json" id="net">)(\s*.*)')
         net_html = net_html.replace(re.findall(pattern, net_html)[-1][-1].strip(), json.dumps

         with open('network.html', 'w') as f:
             f.write(net_html)
```

We'll then `IFrame` in the HTML file

```
In [67]: from IPython.display import IFrame
         IFrame('network.html', width=700, height=900)
```

```
Out[67]: <IPython.lib.display.IFrame at 0x7f5a37abeb00>
```

---

4   Gini Coefficient

Algee-Hewitt was calculating the gini coefficient of the eigenvector centralities. He essentially wanted to know whether importance in a network was evenly distributed, or concentrated in the hands of a few. The lower the gini coefficient, the more equal the distribution, the closer to 1, the closer one gets to complete inequality. I've found a function online that will calculate the gini coefficient for you!

```
In [68]: def gini(array):
             """Calculate the Gini coefficient of a numpy array."""
             # https://github.com/oliviaguest/gini
             array = np.sort(array) # values must be sorted
             index = np.arange(1, array.shape[0] + 1) # index per array element
             n = array.shape[0] # number of array elements
             return ((np.sum((2 * index - n  - 1) * array)) / (n * np.sum(array))) #Gini coeff
```

Just to demonstrate, let's make a very unequal array:

```
In [69]: np.concatenate((np.zeros(99), np.ones(1)))
```

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```
Out[69]: array([ 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,
                 0.,  0.,  0.,  0.,  0.,  0.,  0.,  0.,  1.])
```

The gini coefficient should be close to 1:

```
In [70]: gini(np.concatenate((np.zeros(99), np.ones(1))))
```

```
Out[70]: 0.98999999999999999
```

What if we have half zeroes and half ones?

```
In [71]: gini(np.concatenate((np.zeros(50), np.ones(50))))
```

```
Out[71]: 0.5
```

All ones?

```
In [72]: gini(np.ones(50))
```

```
Out[72]: 0.0
```

Now we can use the `gini` function on *Othello* to see how evenly distributed centrality is:

```
In [73]: import numpy as np
         gini(network_tab['Eigenvector Centrality'])
```

```
Out[73]: 0.4711671341520931
```

Great, but that's not terribly interesting itself, we want to see how it relates to other plays. We'll do that for homework.

First, let's write a function to calculate Algee-Hewitt's second measure. He takes the percentage of characters in the top quartile of eigenvector centralities. You'll want to use the `np.percentile` method!

4.1 Challenge

```
In [76]: def percentage_top_quartile(character_table):
             # YOUR CODE HERE

             return percentage
```

```
In [75]: percentage_top_quartile(network_tab['Eigenvector Centrality'])
```

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```
        -------------------------------------------------------------------------

        NameError                                Traceback (most recent call last)

        <ipython-input-75-63dabf952d04> in <module>()
   ----> 1 percentage_top_quartile(network_tab['Eigenvector Centrality'])


        <ipython-input-74-3a0b1ccd6b68> in percentage_top_quartile(character_table)
          2      # YOUR CODE HERE
          3
   ----> 4      return percentage


        NameError: name 'percentage' is not defined
```

5 Homework

I've downloaded 40 other Shakespeare texts in the exact same XML structure.

```python
In [107]: with open("shakespeare_data/plays_xml/macbeth_ps_v3.xml") as f:
              othello_xml = etree.fromstring(f.read().encode())
```

```python
In [88]: !ls shakespeare_data/plays_xml/
```

```
alls_well_that_ends_well_ps_v3.xml   macbeth_ps_v3.xml
antony_cleopatra_ps_v3.xml             measure_for_measure_ps_v3.xml
as_you_like_it_ps_v3.xml            merchant_of_venice_ps_v3.xml
comedy_of_errors_ps_v3.xml           merry_wives_of_windsor_ps_v3.xml
coriolanus_ps_v3.xml                   midsummer_nights_dream_ps_v3.xml
cymbeline_ps_v3.xml                   much_ado_about_nothing_ps_v3.xml
double_falsehood_ps_v3.xml            othello_ps_v3.xml
edward_iii_ps_v3.xml                   pericles_ps_v3.xml
hamlet_ps_v3.xml                     richard_iii_ps_v3.xml
henry_iv_pt1_ps_v3.xml                 romeo_and_juliet_ps_v3.xml
henry_iv_pt2_ps_v3.xml                 sir_thomas_more_ps_v3.xml
henry_viii_ps_v3.xml                  taming_of_the_shrew_ps_v3.xml
henry_vi_pt1_ps_v3.xml                 tempest_ps_v3.xml
henry_vi_pt2_ps_v3.xml                 timon_of_athens_ps_v3.xml
henry_vi_pt3_ps_v3.xml                 titus_andronicus_ps_v3.xml
henry_v_ps_v3.xml                   troilus_and_cressida_ps_v3.xml
julius_caesar_ps_v3.xml                 twelfth_night_ps_v3.xml
king_john_ps_v3.xml                   two_gentlemen_of_verona_ps_v3.xml
king_lear_ps_v3.xml                   two_noble_kinsmen_ps_v3.xml
king_richard_ii_ps_v3.xml           winters_tale_ps_v3.xml
loves_labours_lost_ps_v3.xml
```

Write some code to loop through at least 5 of these plays and print the most central character in each play according to eigenvector centrality:

```
In [170]: with open("shakespeare_data/plays_xml/as_you_like_it_ps_v3.xml") as f:
              AYLI_xml = etree.fromstring(f.read().encode())

In [171]: all_elements_AYLI= list(AYLI_xml.iter())
          all_elements_AYLI

Out[171]: [<Element play at 0x7f5a36873ac8>,
           <Element title at 0x7f5a37e7ce48>,
           <Element playwright at 0x7f5a37e7ce88>,
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```

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```

```
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             ...]

In [187]: set([e.text for e in all_elements_AYLI if e.tag == "speaker"])

Out[187]: {'1. LORD. ARD.',
           '1. LORD. COURT.',
           '1. PAGE.',
           '2. LORD. ARD.',
           '2. LORD. COURT.',
           '2. PAGE.',
           'ADAM.',
           'AMI.',
           'AUD.',
           'CEL.',
           'CHA.',
           'COR.',
           'DEN.',
           'DUKE F.',
           'DUKE S.',
           'HYM.',
           'JAQ.',
           'JAQ. DE B.',
           'LE BEAU.',
           'OLI.',
           'ORL.',
           'PHE.',
           'ROS.',
           'SIL.',
           'SIR OLI.',
           'TOUCH.',
           'WILL.'}

In [188]: def get_cast_dict(all_elements_AYLI):
              '''
              returns a dictionary with the total number of lines and scenes a character appea
              '''

              cast_dict = {}

              # first get a unique set of all characters appearing in the play
              for c in set([e.text for e in all_elements_AYLI if e.tag == "speaker"]):
                  cast_dict[c] = {"num_lines": 0,
                                  "scenes": []}

              # extract all scene elements from the xml
              scenes = [e for e in all_elements_AYLI if e.tag == "scene"]
              acts = [e for e in all_elements_AYLI if e.tag == "act"]
```

```python
        # acts = [e.find("acttitle").text for e in all_elements if e.tag == "act"]

        for a in acts:

            # get title of acts
            act_title = a.find("acttitle").text

            # get scene elements
            scenes = [e for e in a if e.tag == "scene"]
            # iterate through each scene
            for sc in scenes:

                # grab all the speeches in the scene
                speeches = [s for s in sc.getchildren() if s.tag == "speech"]

                # iterate through speeches
                for s in speeches:

                    # increment number of lines for the speaker
                    cast_dict[s.find("speaker").text]["num_lines"] += len(s.findall("line

                # find all the speaker for each speech
                speakers = [s.find("speaker").text for s in speeches]

                # add the title of the scene for each speaker appearing in the scene
                for s in set(speakers):
                    cast_dict[s]["scenes"].append(act_title + " " + sc.find("scenetitle")

            # reassign scenes to only a unique set
            for c in cast_dict.keys():
                cast_dict[c]["scenes"] = list(set(cast_dict[c]["scenes"]))

        return cast_dict

In [189]: cast_dict = get_cast_dict(all_elements_AYLI)
          cast_dict


        ---------------------------------------------------------------------------

        AttributeError                            Traceback (most recent call last)

        <ipython-input-189-943a4adf6829> in <module>()
    ----> 1 cast_dict = get_cast_dict(all_elements_AYLI)
          2 cast_dict


        <ipython-input-188-c48bff1bb5f0> in get_cast_dict(all_elements_AYLI)
```

```
       33
       34                        # increment number of lines for the speaker
 ---> 35                        cast_dict[s.find("speaker").text]["num_lines"] += len(s.findall("l
       36
       37                    # find all the speaker for each speech


        AttributeError: 'NoneType' object has no attribute 'text'
```

```python
In [165]: def make_graph(c_dict):
              '''
              This function accepts a dictionary with number of lines and scenes to create a
              NetworkX graph object
              '''
              # setup graph object
              G = nx.Graph()

              # add nodes with attributes of number of lines and scenes
              for c in c_dict.keys():
                  if c_dict[c]["num_lines"] > 0:
                      G.add_node(
                          c,
                          number_of_lines=c_dict[c]["num_lines"],
                          scenes=c_dict[c]["scenes"]
                      )

              # make edges by iterating over all combinations of nodes
              for (node1, data1), (node2, data2) in itertools.combinations(G.nodes(data=True),

                  # count scenes together by getting union of their sets
                  scenes_together = len(set(data1['scenes']) & set(data2['scenes']))

                  if scenes_together:
                      # add more weight for more scenes together
                      G.add_edge(node1, node2, weight=scenes_together)

              return G

In [166]: G = make_graph(cast_dict_macbeth)

In [167]: ec = [x[1] for x in sorted(nx.eigenvector_centrality(G).items(), key=lambda x: x[0])]
          network_tab.append_column(label="Eigenvector Centrality", values=ec)
          network_tab.show()

<IPython.core.display.HTML object>


In [168]: import numpy as np
          gini(network_tab['Eigenvector Centrality'])
```
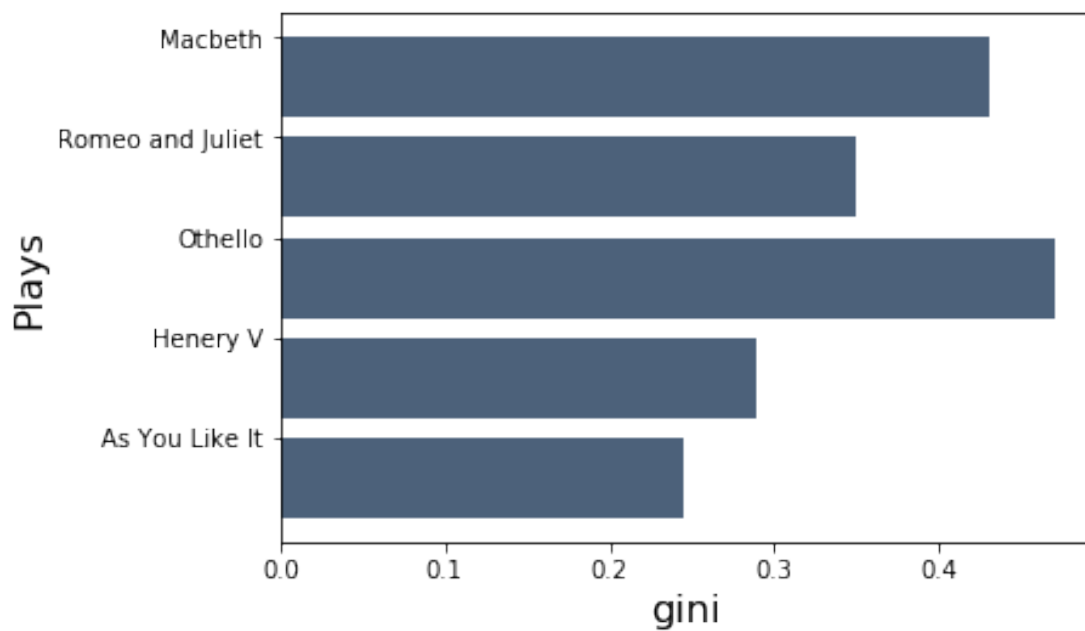
Now use the `gini` function to calculate the gini coefficient of the eigenvector centralities for each of the 5 plays and create a bar chart. Do the same for the percentage in the top quartile. What do these results mean?

```
In [196]: table_gini=Table().with_columns(
              'Plays', make_array('Macbeth', 'Romeo and Juliet', 'Othello','Henery V','As You
              'gini', make_array(0.43, 0.349,0.47,0.28873,0.2449)
          )
```

```
In [197]: table_gini.barh('Plays', 'gini')
```


Much of this code is adapted from http://www.adampalay.com/blog/2015/04/17/shakespeare-social-networks/ .