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BDA LAB 06

Implementation of PageRank

In [ ]:

```
%pylab notebook
import numpy as np
import numpy.linalg as la
np.set_printoptions(suppress=True)
```

```
Populating the interactive namespace from numpy and matplotlib
```

In [ ]:

```
L = np.array([[0,   1/2, 1/3, 0, 0,   0 ],
              [1/3, 0,   0,   0, 1/2, 0 ],
              [1/3, 1/2, 0,   1, 0,   1/2 ],
              [1/3, 0,   1/3, 0, 1/2, 1/2 ],
              [0,   0,   0,   0, 0,   0 ],
              [0,   0,   1/3, 0, 0,   0 ]])
```

In [ ]:

```
eVals, eVecs = la.eig(L) # Gets the eigenvalues and vectors
order = np.absolute(eVals).argsort()[::-1] # Orders them by their eigenvalues
eVals = eVals[order]
eVecs = eVecs[:,order]

r = eVecs[:, 0] # Sets r to be the principal eigenvector
100 * np.real(r / np.sum(r))
```

Out[3]:

```
array([16.        ,  5.33333333, 40.        , 25.33333333,  0.        ,
       13.33333333])
```

In [ ]:

```
r = 100 * np.ones(6) / 6 # Sets up this vector (6 entries of 1/6 × 100 each)
r # Shows it's value
```

Out[4]:

```
array([16.66666667, 16.66666667, 16.66666667, 16.66666667, 16.66666667,
       16.66666667])
```

In [ ]:

```
for i in np.arange(100) : # Repeat 100 times
    r = L @ r
r
```

Out[5]:

```
array([16.        ,  5.33333333, 40.        , 25.33333333,  0.        ,
       13.33333333])
```

In [ ]:

```
r = 100 * np.ones(6) / 6 # Sets up this vector (6 entries of 1/6 × 100 each)
lastR = r
r = L @ r
i = 0
while la.norm(lastR - r) > 0.01 :
    lastR = r
    r = L @ r
    i += 1
print(str(i) + " iterations to convergence.")
r
```

```
18 iterations to convergence.
```

Out[6]:

```
array([16.00149917,  5.33252025, 39.99916911, 25.3324738 ,  0.        ,
       13.33433767])
```

In [ ]:

```
 # We'll call this one L2, to distinguish it from the previous L.
L2 = np.array([[0,   1/2, 1/3, 0, 0,   0, 0 ],
               [1/3, 0,   0,   0, 1/2, 0, 0 ],
               [1/3, 1/2, 0,   1, 0,   0, 0 ],
               [1/3, 0,   1/3, 0, 1/2, 0, 0 ],
               [0,   0,   0,   0, 0,   0, 0 ],
               [0,   0,   1/3, 0, 0,   1, 0 ],
               [0,   0,   0,   0, 0,   0, 1 ]])
```

In [ ]:

```
r = 100 * np.ones(7) / 7 # Sets up this vector (7 entries of 1/7 × 100 each)
lastR = r
r = L2 @ r
i = 0
while la.norm(lastR - r) > 0.01 :
    lastR = r
    r = L2 @ r
    i += 1
print(str(i) + " iterations to convergence.")
r
```

```
46 iterations to convergence.
```

Out[9]:

```
array([ 0.01077429,  0.00420324,  0.02131321,  0.01251789,  0.        ,
       85.66547709, 14.28571429])
```

In [ ]:

```
d = 0.5 # Feel free to play with this parameter after running the code once.
M = d * L2 + (1-d)/7 * np.ones([7, 7])
```

In [ ]:

```
r = 100 * np.ones(7) / 7 # Sets up this vector (6 entries of 1/6 × 100 each)
lastR = r
r = M @ r
i = 0
while la.norm(lastR - r) > 0.01 :
    lastR = r
    r = M @ r
    i += 1
print(str(i) + " iterations to convergence.")
r
```

```
8 iterations to convergence.
```

Out[11]:

```
array([13.13619674, 11.11812027, 19.27885503, 14.33173875,  7.14285714,
       20.70651779, 14.28571429])
```

In [ ]:

```
def pageRank(linkMatrix, d) :
    n = linkMatrix.shape[0]
    M = d * linkMatrix + (1-d)/n * np.ones([n, n])
    r = 100 * np.ones(n) / n # Sets up this vector (n entries of 1/n × 100 each)
    last = r
    r = M @ r
    while la.norm(last - r) > 0.01 :
        last = r
        r = M @ r
    return r


def generate_internet(n) :
    c = np.full([n,n], np.arange(n))
    c = (abs(np.random.standard_cauchy([n,n])/2) > (np.abs(c - c.T) + 1)) + 0
    c = (c+1e-10) / np.sum((c+1e-10), axis=0)
    return c
generate_internet(5)
```

Out[12]:

```
array([[1. , 1. , 0. , 0. , 0.2],
       [0. , 0. , 0. , 0. , 0.2],
       [0. , 0. , 0. , 0.5, 0.2],
       [0. , 0. , 0. , 0.5, 0.2],
       [0. , 0. , 1. , 0. , 0.2]])
```

In [ ]:

```
# Test your PageRank method against the built in "eig" method.
# You should see yours is a lot faster for large internets
L = generate_internet(100)
pageRank(L, 1)
```

Out[14]:

```
array([ 0.00091042,  0.00524342,  0.00207543,  0.00275025,  0.00020357,
        0.00020357,  0.00087266,  0.00034501,  0.00038186, 86.32328336,
        0.0067891 ,  0.00194374, 13.41889132,  0.00298866,  0.00478115,
        0.000246  ,  0.00370263,  0.00013285,  0.00049939,  0.00097129,
        0.00354855,  0.00013285,  0.00087008,  0.00674806,  0.00020357,
        0.00123577,  0.00198197,  0.00066667,  0.00334442,  0.00013285,
        0.00029633,  0.00081152,  0.00578797,  0.00285747,  0.00453583,
        0.0004316 ,  0.00316138,  0.00212957,  0.00435434,  0.0024135 ,
        0.0047651 ,  0.00415149,  0.00562363,  0.00486594,  0.00131677,
        0.00092914,  0.00020208,  0.00095812,  0.00290619,  0.00487084,
        0.00447662,  0.00156912,  0.01144081,  0.00643133,  0.00683471,
        0.00187239,  0.01286116,  0.00146668,  0.00013285,  0.00013285,
        0.00254068,  0.00052445,  0.00013285,  0.00129617,  0.00049939,
        0.001503  ,  0.00140682,  0.00013285,  0.00193618,  0.0035234 ,
        0.00035799,  0.00457621,  0.00052445,  0.00103559,  0.00122249,
        0.00332737,  0.00090252,  0.00035799,  0.00013285,  0.00246559,
        0.00540138,  0.00020305,  0.00377635,  0.00294747,  0.00013285,
        0.00013285,  0.00477653,  0.00013285,  0.00020357,  0.00658074,
        0.0002753 ,  0.00865141,  0.01161115,  0.00464104,  0.00137438,
        0.01237378,  0.00386848,  0.00013285,  0.00013285,  0.00358442])
```

In [ ]:

```
eVals, eVecs = la.eig(L) # Gets the eigenvalues and vectors
order = np.absolute(eVals).argsort()[::-1] # Orders them by their eigenvalues
eVals = eVals[order]
eVecs = eVecs[:,order]

r = eVecs[:, 0]
100 * np.real(r / np.sum(r))
```

Out[15]:

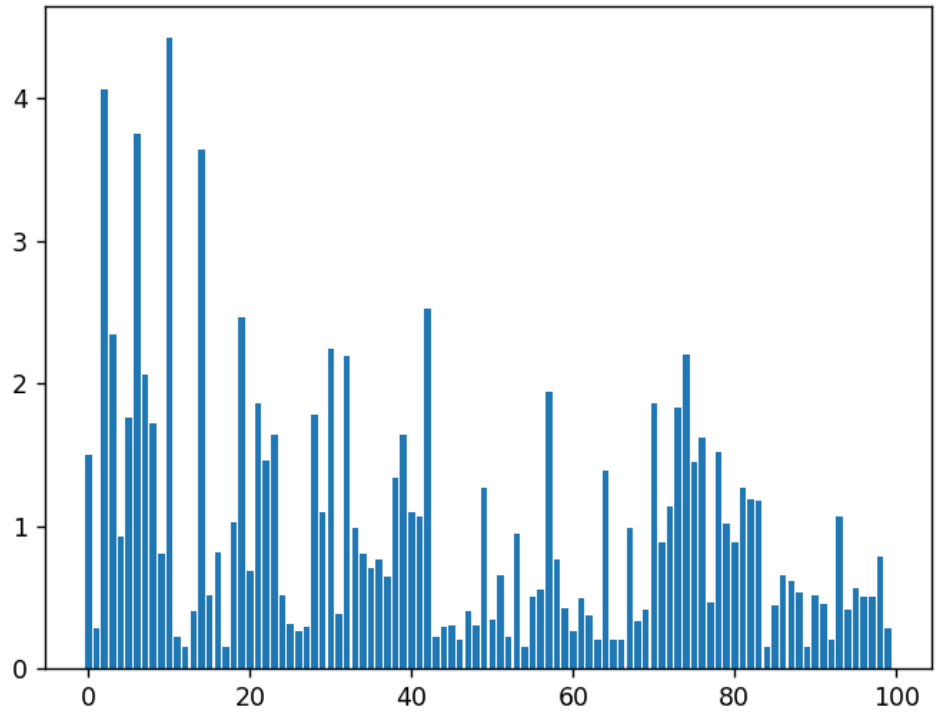
```
array([ 0.00000011,  0.00000048,  0.0000002 ,  0.00000025,  0.00000003,
        0.00000003,  0.0000001 ,  0.00000006,  0.00000006, 86.55040367,
        0.00000067,  0.00000024, 13.44957305,  0.00000032,  0.00000047,
        0.00000004,  0.00000038,  0.00000002,  0.00000006,  0.0000001 ,
        0.00000033,  0.00000002,  0.0000001 ,  0.00000059,  0.00000003,
        0.00000013,  0.00000019,  0.00000008,  0.00000034,  0.00000002,
        0.00000004,  0.0000001 ,  0.00000056,  0.00000027,  0.00000042,
        0.00000007,  0.0000003 ,  0.00000022,  0.0000004 ,  0.00000023,
        0.00000045,  0.00000039,  0.00000048,  0.00000039,  0.00000014,
        0.00000012,  0.00000003,  0.00000011,  0.00000025,  0.00000044,
        0.00000041,  0.00000016,  0.0000009 ,  0.00000054,  0.00000052,
        0.00000017,  0.000001  ,  0.00000015,  0.00000002,  0.00000002,
        0.00000022,  0.00000006,  0.00000002,  0.00000014,  0.00000006,
        0.00000015,  0.00000013,  0.00000002,  0.00000018,  0.00000034,
        0.00000005,  0.00000041,  0.00000006,  0.00000012,  0.00000014,
        0.00000032,  0.0000001 ,  0.00000005,  0.00000002,  0.00000023,
        0.00000048,  0.00000003,  0.00000035,  0.00000026,  0.00000002,
        0.00000002,  0.00000042,  0.00000002,  0.00000003,  0.00000047,
        0.00000004,  0.00000066,  0.00000084,  0.00000035,  0.00000013,
        0.00000089,  0.00000035,  0.00000002,  0.00000002,  0.00000032])
```

In [ ]:

```
# You may wish to view the PageRank graphically.
# This code will draw a bar chart, for each (numbered) website on the generated internet,
# The height of each bar will be the score in the PageRank.
# Run this code to see the PageRank for each internet you generate.
# Hopefully you should see what you might expect
# - there are a few clusters of important websites, but most on the internet are rubbish
%pylab notebook
r = pageRank(generate_internet(100), 0.9)
plt.bar(arange(r.shape[0]), r);
```

```
Populating the interactive namespace from numpy and matplotlib
```

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



Implementation of TextRank

In [30]:

```
import re

import numpy as np
from nltk import sent_tokenize, word_tokenize

from nltk.cluster.util import cosine_distance

MULTIPLE_WHITESPACE_PATTERN = re.compile(r"\s+", re.UNICODE)


def normalize_whitespace(text):
    """
    Translates multiple whitespace into single space character.
    If there is at least one new line character chunk is replaced
    by single LF (Unix new line) character.
    """
    return MULTIPLE_WHITESPACE_PATTERN.sub(_replace_whitespace, text)


def _replace_whitespace(match):
    text = match.group()

    if "\n" in text or "\r" in text:
        return "\n"
    else:
        return " "


def is_blank(string):
    """
    Returns `True` if string contains only white-space characters
    or is empty. Otherwise `False` is returned.
    """
    return not string or string.isspace()


def get_symmetric_matrix(matrix):
    """
    Get Symmetric matrix
    :param matrix:
    :return: matrix
    """
    return matrix + matrix.T - np.diag(matrix.diagonal())


def core_cosine_similarity(vector1, vector2):
    """
    measure cosine similarity between two vectors
    :param vector1:
    :param vector2:
    :return: 0 < cosine similarity value < 1
    """
    return 1 - cosine_distance(vector1, vector2)


'''
Note: This is not a summarization algorithm. This Algorithm pics top sentences irrespect
'''
```

```
class TextRank4Sentences():
    def __init__(self):
        self.damping = 0.85  # damping coefficient, usually is .85
        self.min_diff = 1e-5  # convergence threshold
        self.steps = 100  # iteration steps
        self.text_str = None
        self.sentences = None
        self.pr_vector = None

    def _sentence_similarity(self, sent1, sent2, stopwords=None):
        if stopwords is None:
            stopwords = []

        sent1 = [w.lower() for w in sent1]
        sent2 = [w.lower() for w in sent2]

        all_words = list(set(sent1 + sent2))

        vector1 = [0] * len(all_words)
        vector2 = [0] * len(all_words)

        # build the vector for the first sentence
        for w in sent1:
            if w in stopwords:
                continue
            vector1[all_words.index(w)] += 1

        # build the vector for the second sentence
        for w in sent2:
            if w in stopwords:
                continue
            vector2[all_words.index(w)] += 1

        return core_cosine_similarity(vector1, vector2)

    def _build_similarity_matrix(self, sentences, stopwords=None):
        # create an empty similarity matrix
        sm = np.zeros([len(sentences), len(sentences)])

        for idx1 in range(len(sentences)):
            for idx2 in range(len(sentences)):
                if idx1 == idx2:
                    continue

                sm[idx1][idx2] = self._sentence_similarity(sentences[idx1], sentences[id

        # Get Symmeric matrix
        sm = get_symmetric_matrix(sm)

        # Normalize matrix by column
        norm = np.sum(sm, axis=0)
        sm_norm = np.divide(sm, norm, where=norm != 0)  # this is ignore the 0 element i

        return sm_norm

    def _run_page_rank(self, similarity_matrix):

        pr_vector = np.array([1] * len(similarity_matrix))

        # Iteration
```

```
        previous_pr = 0
        for epoch in range(self.steps):
            pr_vector = (1 - self.damping) + self.damping * np.matmul(similarity_matrix,
            if abs(previous_pr - sum(pr_vector)) < self.min_diff:
                break
            else:
                previous_pr = sum(pr_vector)

        return pr_vector

    def _get_sentence(self, index):

        try:
            return self.sentences[index]
        except IndexError:
            return ""

    def get_top_sentences(self, number=5):

        top_sentences = []

        if self.pr_vector is not None:

            sorted_pr = np.argsort(self.pr_vector)
            sorted_pr = list(sorted_pr)
            sorted_pr.reverse()

            index = 0
            for epoch in range(number):
                sent = self.sentences[sorted_pr[index]]
                sent = normalize_whitespace(sent)
                top_sentences.append(sent)
                index += 1

        return top_sentences

    def analyze(self, text, stop_words=None):
        self.text_str = text
        self.sentences = sent_tokenize(self.text_str)

        tokenized_sentences = [word_tokenize(sent) for sent in self.sentences]

        similarity_matrix = self._build_similarity_matrix(tokenized_sentences, stop_word

        self.pr_vector = self._run_page_rank(similarity_matrix)


text_str = '''
    Those Who Are Resilient Stay In The Game Longer *
    “On the mountains of truth you can never climb in vain: either you will reach a poin
    Challenges and setbacks are not meant to defeat you, but promote you. However, I rea
    '''

tr4sh = TextRank4Sentences()
tr4sh.analyze(text_str)
print(tr4sh.get_top_sentences(5))
```

```
['\nThose Who Are Resilient Stay In The Game Longer *\n“On the mountains o
f truth you can never climb in vain: either you will reach a point higher
up today, or you will be training your powers so that you will be able to
climb higher tomorrow.” – Friedrich Nietzsche\nChallenges and setbacks are
not meant to defeat you, but promote you.', 'To be honest, I don’t have th
e answers.', 'To a person with a Fixed Mindset failure is a blow to their
self-esteem, yet to a person with a Growth Mindset, it’s an opportunity to
improve and find new ways to overcome their obstacles.', 'However, it’s im
portant not to be discouraged by failure when pursuing a goal or a dream,
since failure itself means different things to different people.', 'Howeve
r, I realise after many years of defeats, it can crush your spirit and it
is easier to give up than risk further setbacks and disappointments.']
```

Conclusion - Implemented PAgeRank and TextRank Sucessfully.