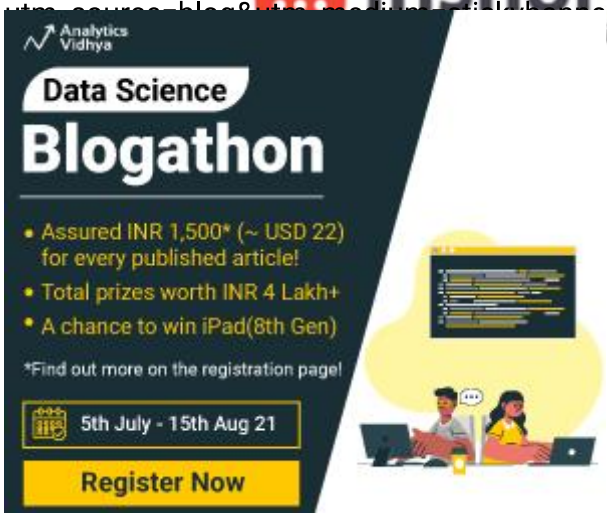
An Introduction to Text Summarization using the TextRank Algorithm (with Python implementation)

PRATEEK JOSHI (HTTPS://WWW.ANALYTICSVIDHYA.COM/BLOG/AUTHOR/PRATEEK/), NOVEMBER 1, 2018

Introduction



Automatic Text Summarization is one of the most challenging and interesting problems in the field of Natural Language Processing (NLP). It is a process of generating a concise and meaningful summary of text from multiple text resources such as books, news articles, blog posts, research papers, emails, and tweets.

The demand for automatic text summarization systems is spiking these days thanks to the availability of large amounts of textual data.

Through this article, we will explore the realms of text summarization. We will understand how the TextRank algorithm works, and will also implement it in Python. Strap in, this is going to be a fun ride!

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1. Text Summarization Approaches
2. Understanding the TextRank Algorithm
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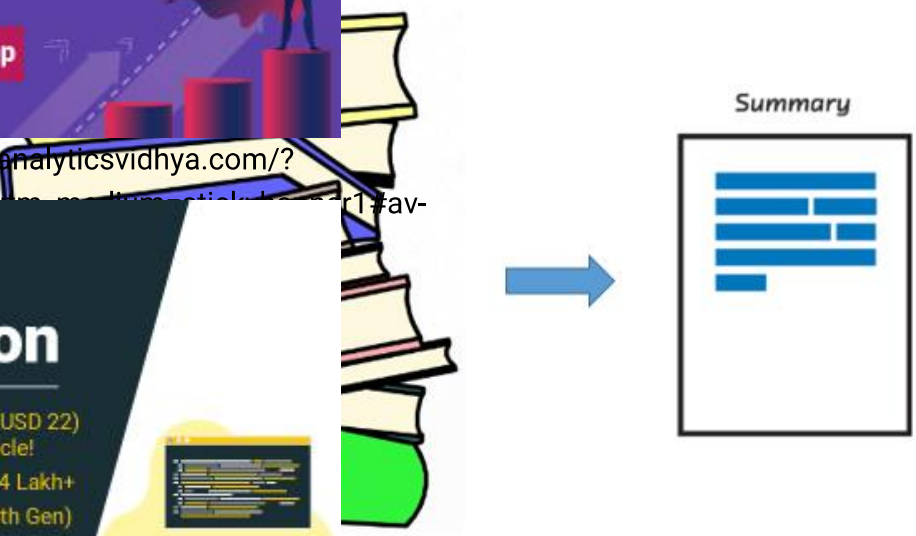


on as early as the 1950's. A research paper /papers/luhn58.pdf), published by Hans Peter Luhn in the late 1950s, titled "The automatic creation of literature abstracts", used features such as word frequency and phrase frequency to extract important sentences from the text for summarization purposes.

Another important research (http://courses.ischool.berkeley.edu/i256/f06/papers/edmonson69.pdf), done by Harold P Edmundson in the late 1960's, used methods like the presence of cue words, words used in the title appearing in the text, and the location of sentences, to extract significant sentences for text summarization. Since then, many important and exciting studies have been published to address the challenge of automatic text summarization.

Text summarization can broadly be divided into two categories — **Extractive Summarization** and **Abstractive Summarization**.

1. **Extractive Summarization:** These methods rely on extracting several parts, such as phrases and sentences, from a piece of text and stack them together to create a summary. Therefore, identifying the

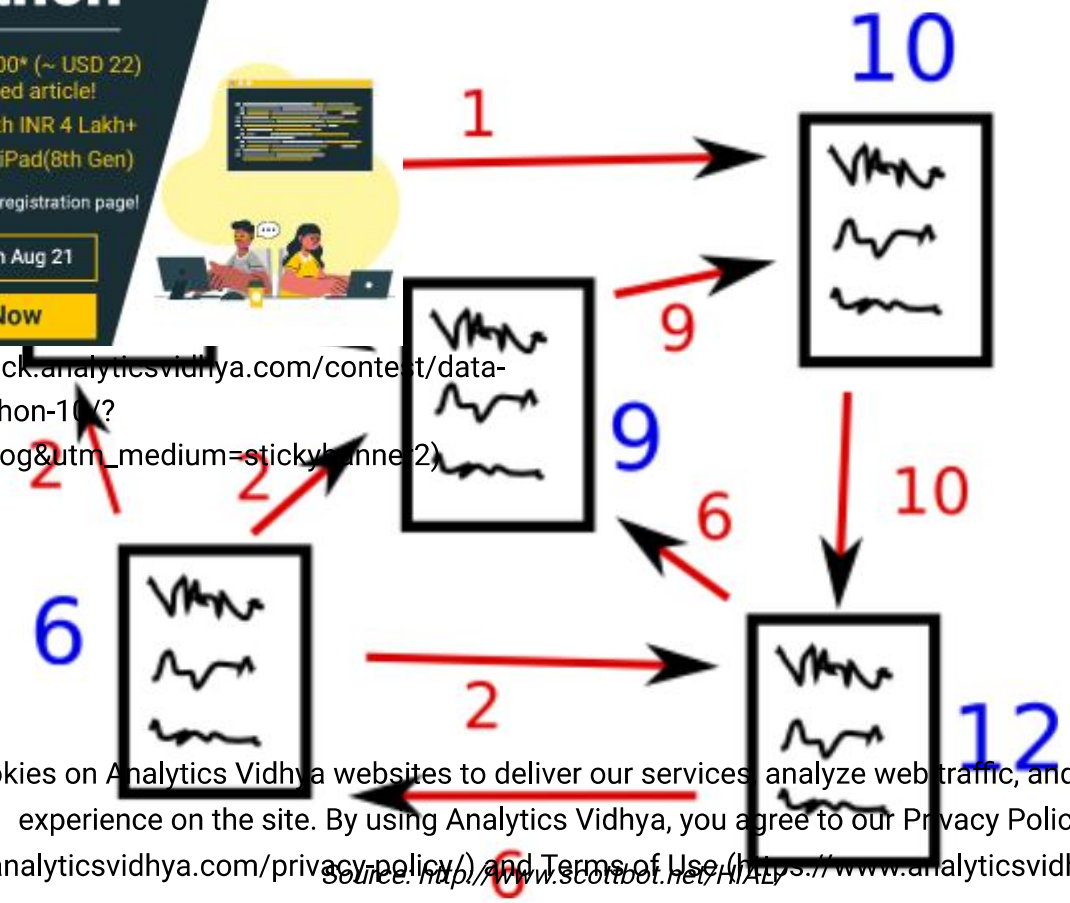
right sentences for summarization is of utmost importance in an extractive method.

2. **Abstractive Summarization:** These methods use
summary. Some parts of this summary may not

ctive sum

thm

rithm, there's another algorithm which we should become familiar ctually inspired TextRank! **PageRank is used primarily for ranking** kly understand the basics of this algorithm with the help of an



Source: http://www.scottbot.net/HIAL/

Suppose we have 4 web pages — w1, w2, w3, and w4. These pages contain links pointing to one another. Some pages might have no link – these are called dangling p

and w4

(https://ascendpro.analyticsvidhya.com/?

- w3 has no links and hence it will be called a dangling page

utm_source=blog&utm_medium=stickybanner1#av-

o compute a score called the **PageRank score**. This score is the

ıg from one page to another, we will create a square **matrix M**, ıumber of web pages.

(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

Each element of this matrix denotes the probability of a user transitioning from one web page to another. For example, the highlighted cell below contains the probability of transition from w1 to w2.

M =	w1	w2	w3	w4
w1				
w2				
w3				
w4				

P(w1 to w2)

The initialization of the probabilities is explained in the steps below:

1. Probability of going from page i to j, i.e., M[i][j], is initialized with **1/(number of unique links in web page wi)**

2. If there is no link between the page i and j, then the probability will be initialized with **0**
3. If a user has landed on a dangling page, then it is
page. Hence, M[i][i] will be initialized with **1/(nu**

ized as fo

d in an iterative fashion to arrive at the web page rankings.

TextRank Algorithm

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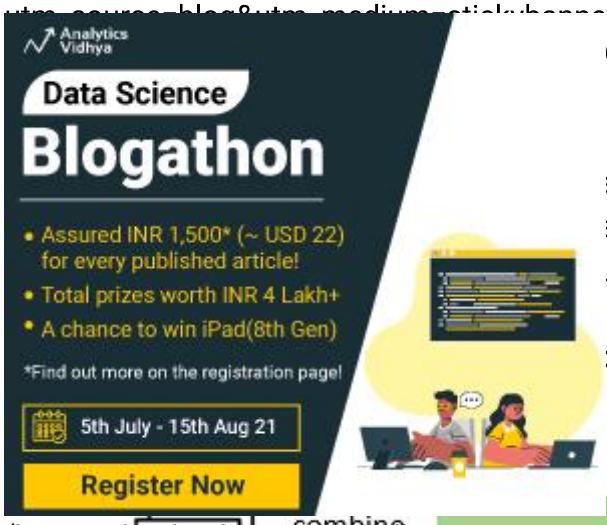
that we have a grasp on PageRank. I have listed the similarities

es

s used as an equivalent to the web page transition probability
uare matrix, similar to the matrix M used for PageRank

ext summarization technique. Let's take a look at the flow of the



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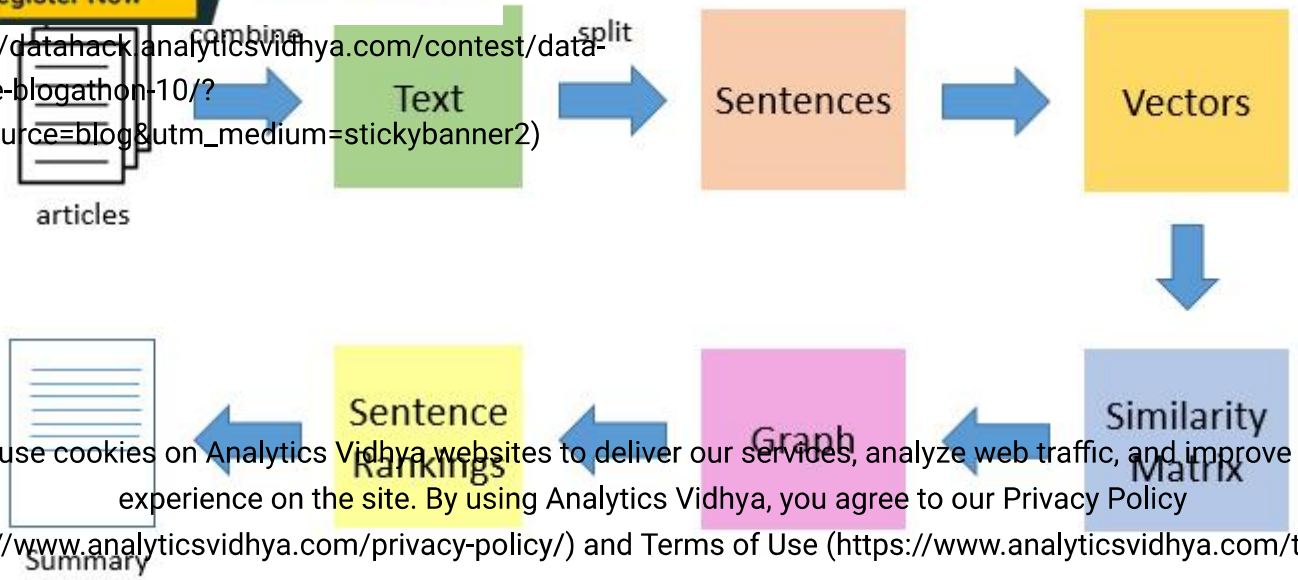

- The first step would be to concatenate all the text contained in the articles
- Then split the text into individual sentences
- In the next step, we will find vector representatio
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- into a gra

sentences

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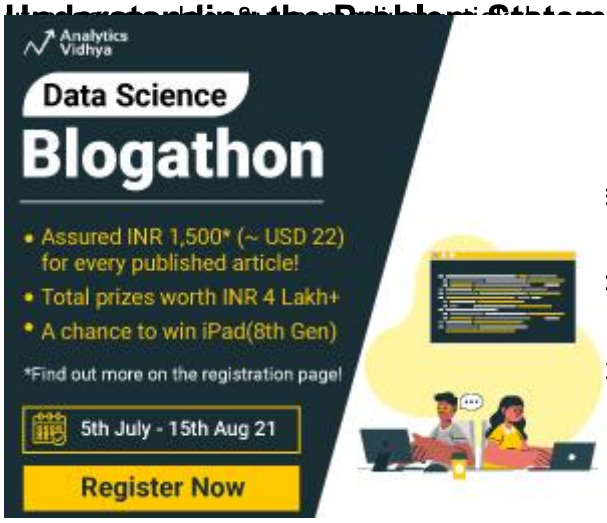
Theory, the

/09/introduction-graph-theory-applications-python/).

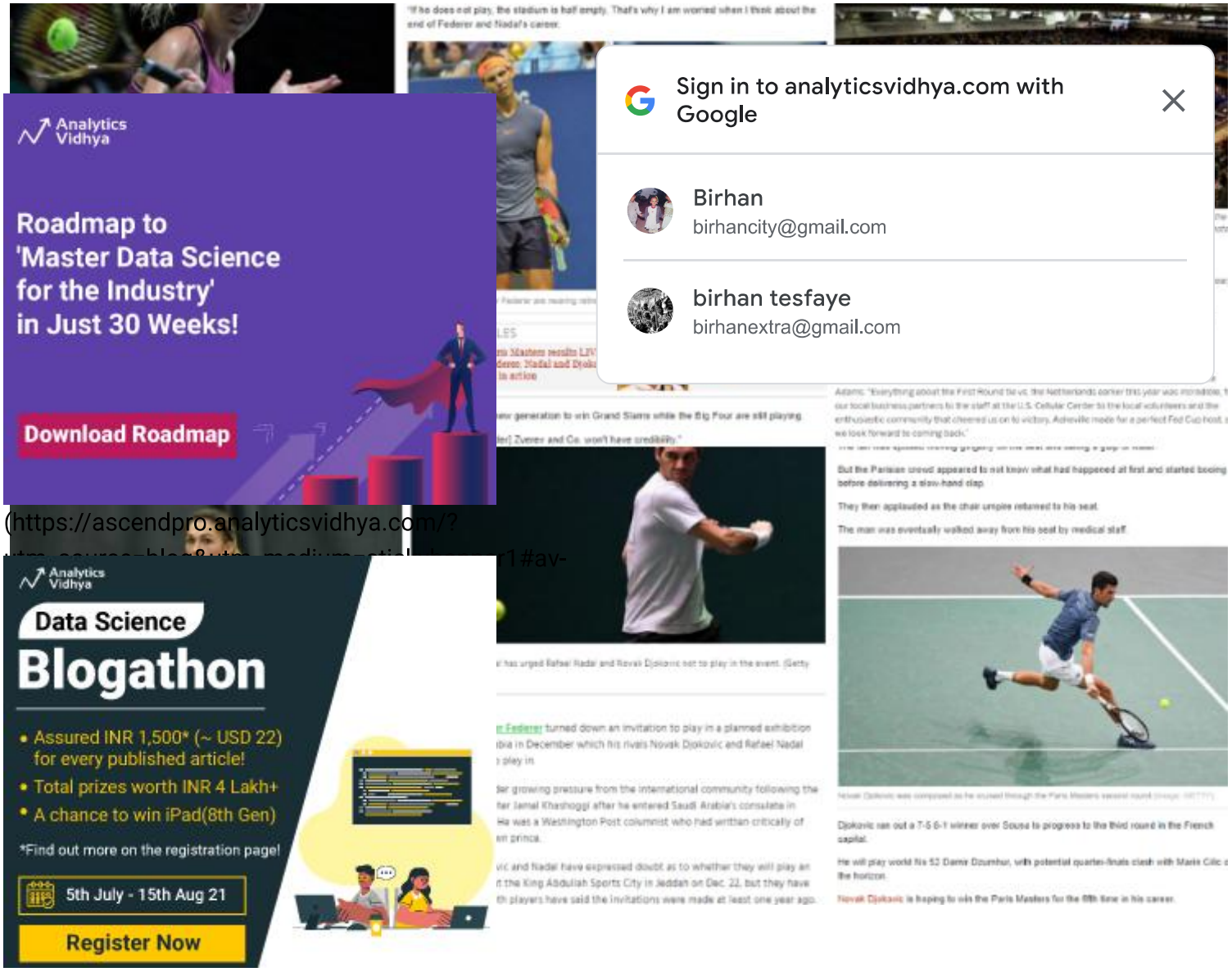
(https://ascendpro.analyticsvidhya.com/?



(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

myself updated with what's happening in the sport by religiously as possible. However, this has proven to be a rather difficult job! s a constraint.

could prepare a bullet-point summary for me by scanning through That's what I'll show you in this tutorial. We will apply the TextRank h the aim of creating a nice and concise summary.



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Please note that this is essentially a single-domain-multiple-documents summarization task, i.e., we will take multiple articles as input and generate a single bullet-point summary. Multi-domain text summarization is not covered in this article, but feel free to try that out at your end.

You can download the dataset we'll be using from here (https://drive.google.com/file/d/1HPShiXSrHMNlfcMZn-WFYjoftitOH9fJ/view?usp=sharing).

Implementation of the TextRank Algorithm

So, without any further ado, fire up your Jupyter Notebooks and let's implement what we've learned so far.

Import Required Libraries

First, import the libraries we'll be leveraging for this cha

on

Read the Data

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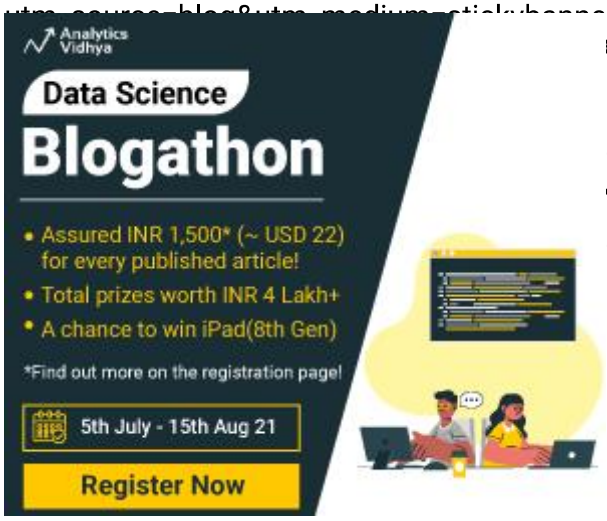
e link to download the data in the previous section (in case you

')



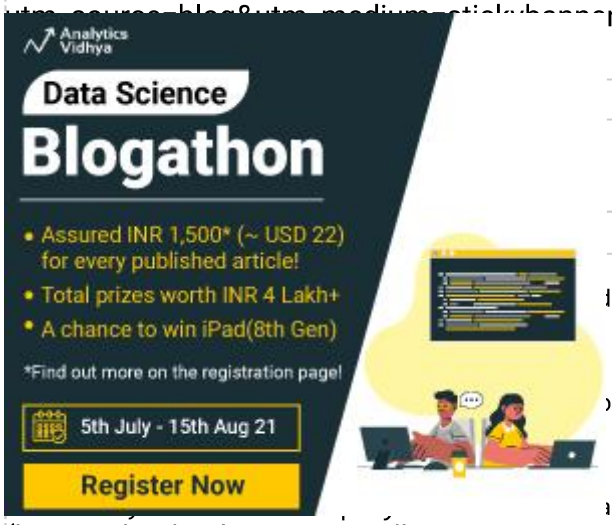
(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?
utm_source=blog&utm_medium=stickybanner2)

df.head()

	article_id	article_text	source
0	1	Maria Sharapova has basically no friends as te...	https://www.tennisworldusa.org/tennis/news/Mar...
1	2	BASEL, Switzerland (AP), Roger Federer advance...	http://www.tennis.com/pro-game/2018/10/copil-s...
2	3	Roger Federer has revealed that organisers of ...	https://scroll.in/field/899938/tennis-roger-fe...
3	4	Kei Nishikori will try to end his long losing ...	http://www.tennis.com/pro-game/2018/10/nishiko...
4	5	Federer 37 first broke through on tour aweek ...	https://www.express.co.uk/sport/tennis/1036101...

We have 3 columns in our dataset – 'article_id', 'article
'article_text' column as it contains the text of the articl


```
s as tennis players on the WTA Tour. The Russian player
it and in a recent interview she said: 'I don't really
vone knows this is my job here. When I'm on the courts
 on when I'm on the court playing, I'm a competitor and I want to beat every single person whether
net...
```

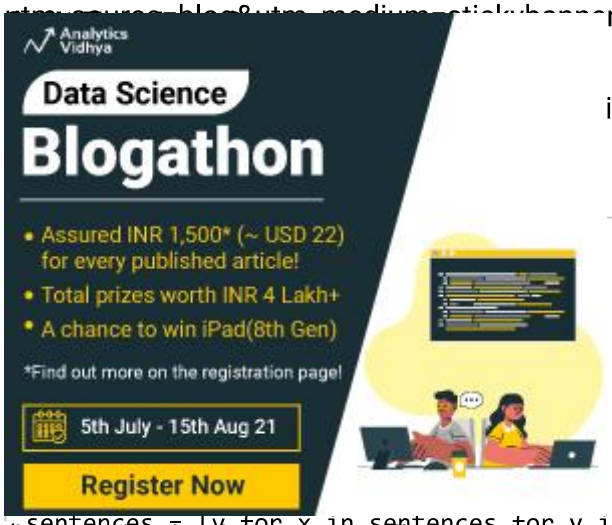



```
dvanced to the 14th Swiss Indoors final of his career by beat

n Saturday. Seeking a ninth title at his hometown event, and

arius Copil on Sunday. Federer dominated the 20th-ranked Medv
 edev and had
 his first match-point chance to break serve again at 5-1...
```

```
df['article_text'][2]
```

```
Roger Federer has revealed that organisers of the re-launched and condensed Davis Cup gave him three
days to
```


(https://ascendpro.analyticsvidhya.com/?



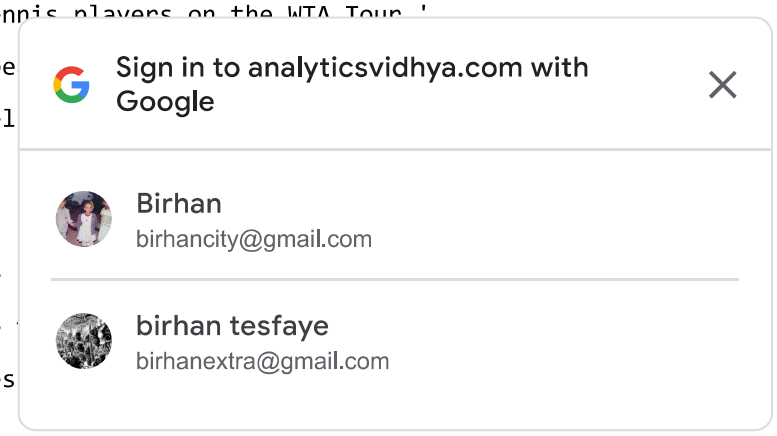
(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?

Let's print a few elements of the list *sentences*:

```
sentences[:5]
```

Output:

```
['Maria Sharapova has basically no friends as tennis players on the WTA Tour.'
"The Russian player has no problems in openly spe                    any feel
                                                                     ere.',
                                                                     he court
                                                                     single
                                                                     the one
                                                                     minutes
```



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Download GloVe Word Embeddings

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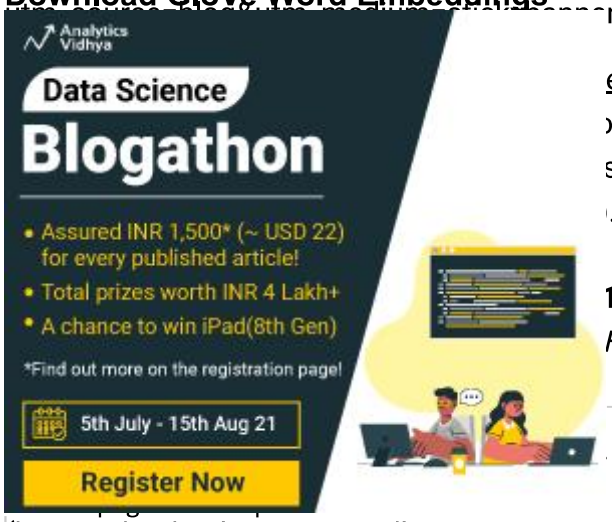


e/) word embeddings are vector representation of words. These
ors for our sentences. We could have also used the Bag-of-Words or
sentences, but these methods ignore the order of the words (and
.

14 + Gigaword 5 GloVe vectors available here

Heads up – the size of these word embeddings is 822 MB.

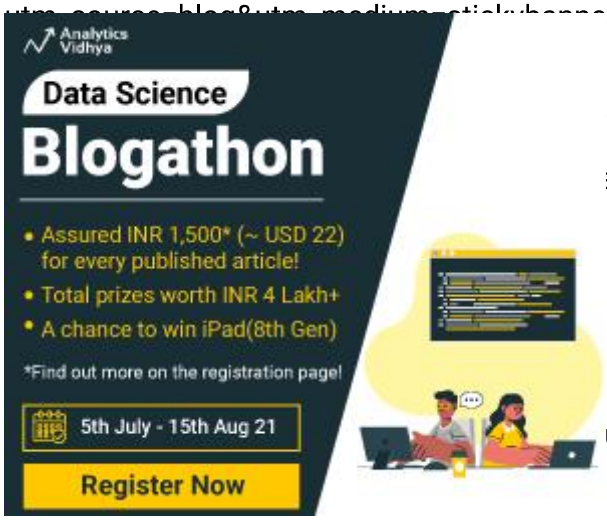
```
6B.zip
```

(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

Let's extract the words embeddings or word vectors.

```
# Extract word vectors
word_embeddings = {}
```


(https://ascendpro.analyticsvidhya.com/?



(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

```
# remove punctuations, numbers and special characters
clean_sentences = pd.Series(sentences).str.replace("[^a-zA-Z]", " ")


# make alphabets lowercase
clean_sentences = [s.lower() for s in clean_sentences]
```

Get rid of the stopwords (commonly used words of a language – is, am, the, of, in, etc.) present in the sentences.

If you have not downloaded *nltk-stopwords*, then execute the following line of code.

```
nltk.download('stopwords')
```

Now we can import the stopwords.

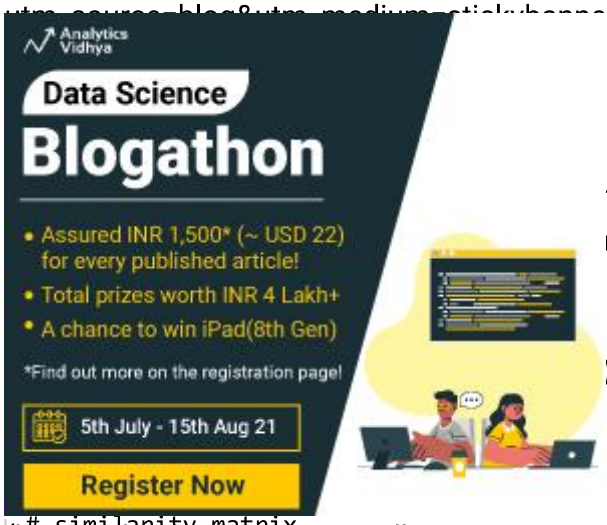

```
word_embeddings = {}
f = open('glove.6B.100d.txt', encoding='utf-8')
for line in f:
    values = line.split()
    word = values[0]
    coefs = np.asarray(values[1:], dtype='float32')
    word_embeddings[word] = coefs
f.close()
```


Now, let's create vectors for our sentences. We will first fetch vectors (each of size 100 elements) for the constituent words in a sentence and then take mean/average of those vectors to arrive at a consolidated vector for the sentence.

```
sentence_vectors = []
for i in clean_sentences:
```


ices, you may check out the video course, Natural Language Processing svidhya.com/courses/course- ?utm_source=blog&utm_medium=introduction-text-summarization-

(https://ascendpro.analyticsvidhya.com/?
r1#av-



(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

ne sentences, and we will use the cosine similarity approach for this
ıtrix for this task and populate it with cosine similarities of the

(n * n). We will initialize this matrix with cosine similarity scores of
nces.

```
# similarity matrix
sim_mat = np.zeros([len(sentences), len(sentences)])
```

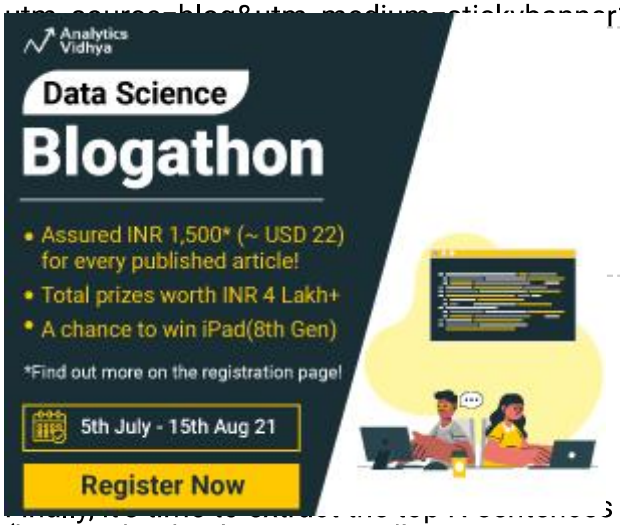
We will use Cosine Similarity to compute the similarity between a pair of sentences.

```
from sklearn.metrics.pairwise import cosine_similarity
```

And initialize the matrix with cosine similarity scores.

```
for i in range(len(sentences)):
  for j in range(len(sentences)):
```


milarity matrix *sim_mat* into a graph. The nodes of this graph will present the similarity scores between the sentences. On this graph, we will apply the PageRank algorithm to arrive at the sentence rankings.



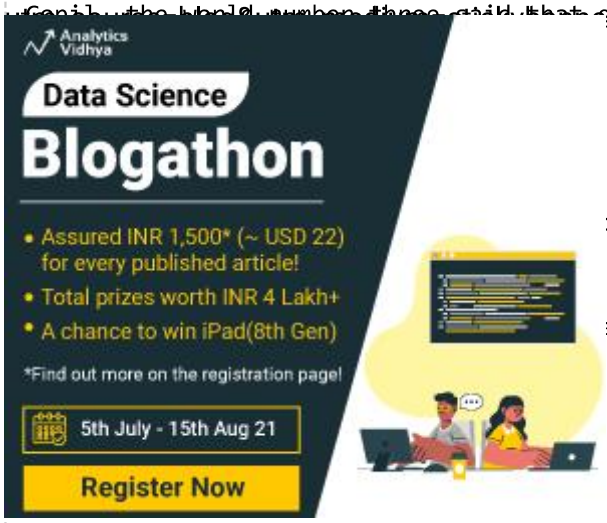
s based on their rankings for summary generation.


```
ranked_sentences = sorted((scores[i],s) for i,s in enumerate(sentences), reverse=True)
```

```
# Extract top 10 sentences as the summary
for i in range(10):
  print(ranked_sentences[i][1])
```

When I'm on the courts or when I'm on the court playing, I'm a competitor and I want to beat every si
ngle person
across the
nutes I h
ate Novem

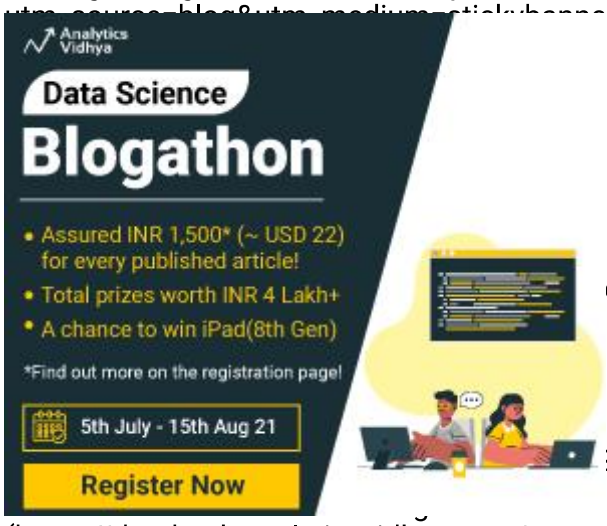
where he will play in Sundays final against Romanian qualifi
er Marius
Cenik, the world number three said that given the impossibly short time frame to make a decision, he
get to know players when I was playing were the Fed Cup wee
tournaments.
a win could move to within 125 points of the cut for the eig
ht London next month.



He used his first break point to close out the first set before going up 3-0 in the second and wrappi
ng up the
win on his first match point.
The Spaniard broke Anderson twice in the second but didn't get another chance on the South African's
serve in the
final set.

"We also had the impression that at this stage it might be better to play matches than to train.
The competition is set to feature 18 countries in the November 18-24 finals in Madrid next year, and

```
will replace
the classic home-and-away ties played four times
```

and usef

of research, and in this article, we have covered just the tip of the iceberg. Going forward, we will explore the abstractive text summarization technique where deep learning plays a following summarization tasks:

urce in some language and summary in another language)

STM

nt Learning

- Text summarization using Generative Adversarial Networks (GANs)

End Notes

I hope this post helped you in understanding the concept of automatic text summarization. It has a variety of use cases and has spawned extremely successful applications. Whether it's for leveraging in your business, or just for your own knowledge, text summarization is an approach all NLP enthusiasts should be familiar with.

I will try to cover the abstractive text summarization technique using advanced techniques in a future article. Meanwhile, feel free to use the comments section below to let me know your thoughts or ask any questions you might have on this article.

Please find the code in this GitHub Repo (https://github.com/prateekjoshi565/textrank_te

CSVIDHYA.COM/BLOG/TAG/ADVANCED-PYTHON/), GLOVE
GLOVE/), NATURAL LANGUAGE PROCESSING
NATURAL-LANGUAGE-PROCESSING/), NLP
NLP/), TEXT MINING (HTTPS://WWW.ANALYTICSVIDHYA.COM/BLOG/TAG/TEXT-
TICSVIDHYA.COM/BLOG/TAG/WORD-EMBEDDING/)

NEXT ARTICLE

Top 5 Machine Learning GitHub Repositories & Reddit Discussions (October 2018)
(https://www.analyticsvidhya.com/blog/2018/11/best-machine-learning-github-repositories-reddit-threads-october-2018/)

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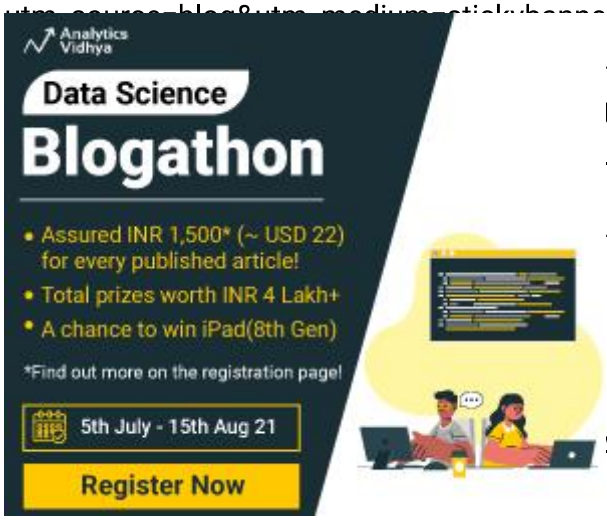
PREVIOUS ARTICLE

DataHack Radio #13: Data Science and AI in the Oil & Gas Industry with Yogendra Pandey, Ph.D.
(https://www.analyticsvidhya.com/blog/2018/10/datahack-radio-podcast-oil-gas-ai/)

(https://ascendpro.analyticsvidhya.com/?utm_source=blog&utm_medium=stickybanner1#av-



(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

Hi Prateek,

Thanks for sharing. Since I'm an absolute beginner, hope you don't me asking. Why did I get this error & how do I fix this? Thanks.

NameError Traceback (most recent call last)
in ()
1 for s in df ['article_text']:
—-> 2 sentences.append (sent_tokenize(s))
3 sentences = [y for x in sentences for y in x] #flatten list

NameError: name 'sentences' is not defined

PRATEEK JOSHI Reply

November 2, 2018 at 10:56 am (https://www.analyticsv

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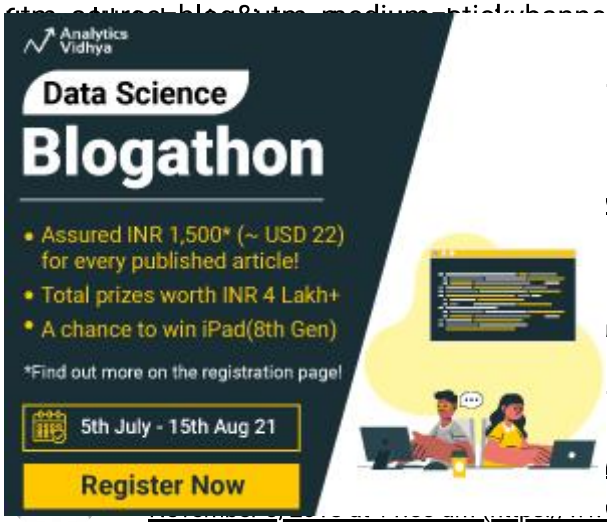
y.

.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

point out a minor oversight.

(https://apc.pro.analyticsvidhya.com/?utm_source=blog&utm_medium=stickybanner1#av-

Please add import of sent_tokenize into the corresponding section.



Reply

w.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

ted the same.

/.PSYFING.COM) **Reply**

w.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-155627)

(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

Thank you Prateek. Learnt something new today.

I've attempted to answer the same using n-gram frequency for sentence weighting. The results differ a bit. Shorter sentences come thru textrank which does not in case of n-gram based.

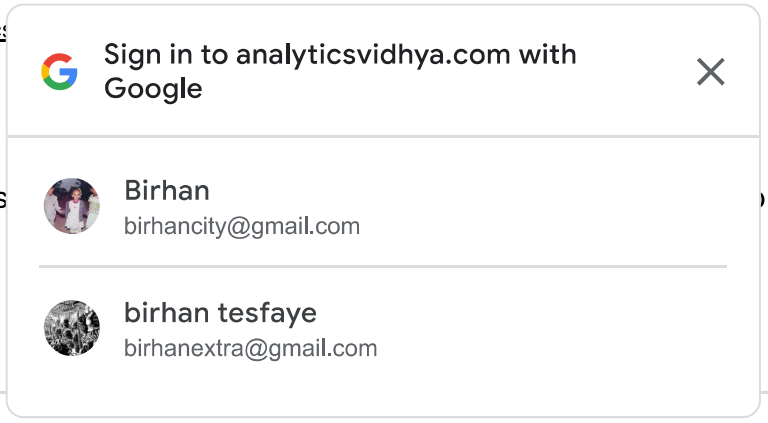
It is here:
https://github.com/SanjayDatta/n_gram_Text_Summary/blob/master/A1.ipynb (https://github.com/SanjayDatta/n_gram_Text_Summary/blob/master/A1.ipynb)

Would be happy to know your views.

Regards.

ROCA **Reply**

November 10, 2018 at 10:53 pm (https://www.analytics



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Reply

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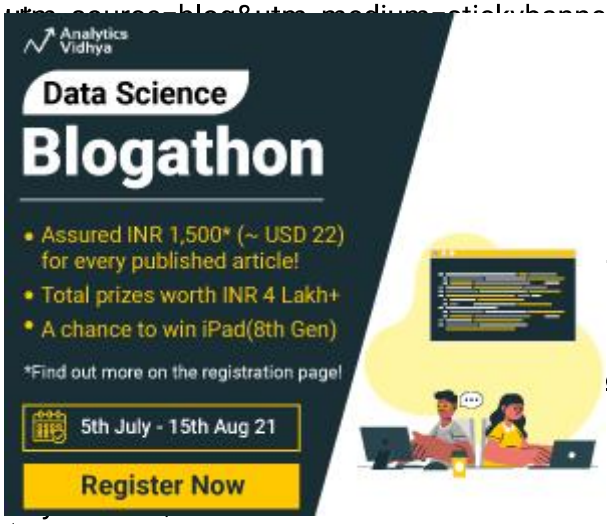



```
ce_vectors[i].reshape(1,100), sentence_vectors[j].reshape(1,1
```

Reply

ww.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

(https://datahack.analyticsvidhya.com/contest/data-
science-blogathon-10/?
utm_source=blog&utm_medium=stickybanner2)

I tried your suggestion but I am still getting the error :(...I have a single line for sim_mat[i][j]. Is it possible that it is because of a mistake earlier in the code? I look for any issue, even checked your github...Is there anything else to try?

TYSON **Reply**

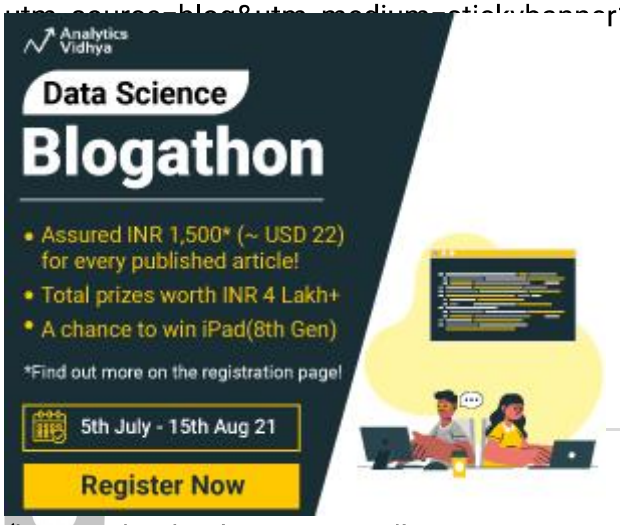
March 28, 2019 at 2:39 am (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-157597)

ROCA Check the placement of sentence_vectors.append() in

```
"isentence_vectors = []
for i in clean_sentences:
if len(i) != 0:
```

```
v = sum([word_embeddings.get(w, np.zeros((100,))) for w in i.split()])/(len(i.split())+0.001)
else:
v = np.zeros((100,))
```


(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner1#av-first step.



(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

Reply

November 17, 2018 at 11:11 am (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-155755)

Hi Arpit,

Please use indentation properly in your code.

SACHIN KALSI (HTTPS://SACHINKALSI.GITHUB.IO/) **Reply**

December 26, 2018 at 11:30 am (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-156304)

Good one indeed. Waiting for your next article Prateek. Specially on “using RNN’s & LSTM’s to summarise text”

SHENG-FENG Reply

January 8, 2019 at 1:00 pm (https://www.analyticsvidh

e field of N

(https://datahack.analyticsvidhya.com/?
utm_source=blog&utm_medium=stickybanner1#av-

(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

(i=pca.fit(word_embeddings.get(w, np.zeros((100,))) for w in i.split())/(len(i.split())+0.001)

i character and not the word right?

/ than the character and character similarity?

Reply

nalyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

I am glad that you found my article helpful. The ‘w’ would be a word and not a character.

PUNEET SINHA Reply

January 10, 2019 at 12:31 pm (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-156503)

networkx dont have any funtion like “from_numpy_array” could you please recheck?

nx_graph = nx.from_numpy_array(sim_mat)

PRATEEK JOSHI Reply

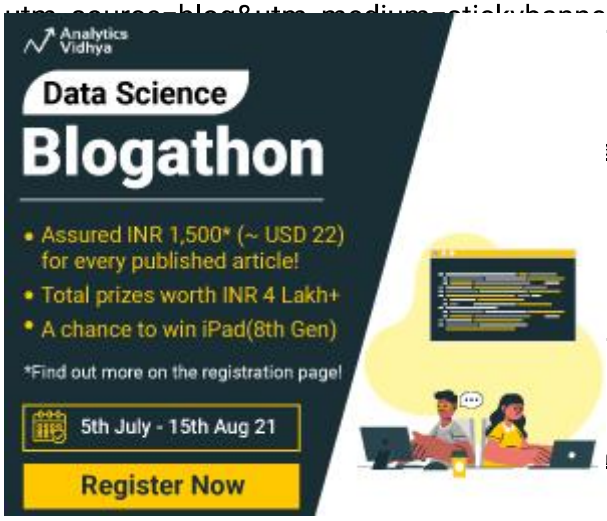
January 12, 2019 at 1:23 pm (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-156546)

an check
able/refer
table/refe
arr
ar

Reply

lyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

Is it from numpy.matrix instead of from numpy_array?
(https://ascendpro.analyticsvidhya.com/?
r1#av-



Reply

lyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

Reply

lyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

(https://datahack.analyticsvidhya.com/contest/data-
utm_source=blog&utm_medium=stickybanner2)

I have updated to networkx 2.0 now the function is “nx.from_numpy_array”

SARUUL Reply

April 6, 2019 at 4:15 am (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-157743)

Same problem I get:

AttributeError: module ‘networkx’ has no attribute ‘from_numpy_array’

Any ideas?

PRATEEK JOSHI Reply

April 22, 2019 at 11:46 am (https://www.analyticsvidhy

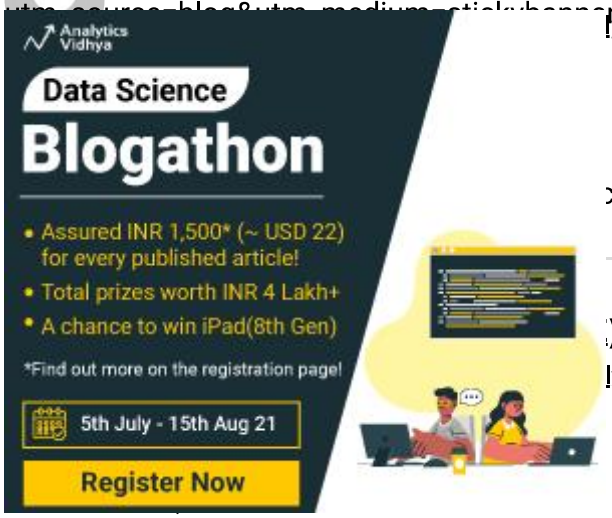
ticsvidhya.c y

echnique discussed?

(https://ascendpro.analyticsvidhya.com/?

GLOBAL WARMING Reply

lyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-



ch time

) Reply

lyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-

(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

For this section:

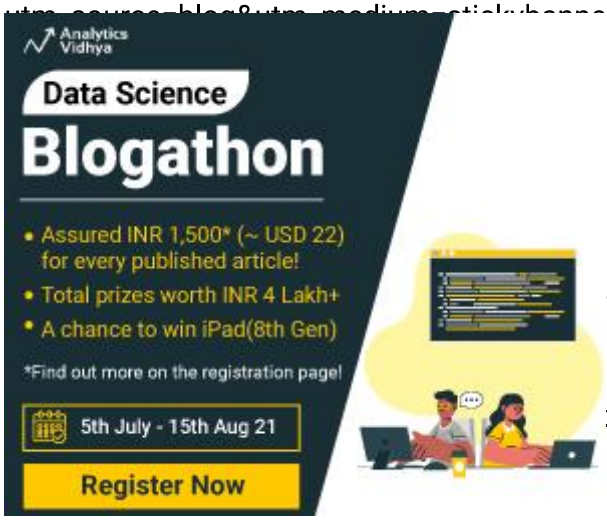
```
for i in clean_sentences:
if len(i) != 0:
v = sum([word_embeddings.get(w, np.zeros((100,))) for w in i.split()])/(len(i.split())+0.001))
else:
v = np.zeros((100,))
sentence_vectors.append(v)
```

When I copy the code up to here I receive error "operands could not be broadcast together with shapes (300,) (100,)".

When isolating it, I found that it happens at this part:

```
sum([word_embeddings.get(w, np.zeros((100,))) for w in i.split()])
```

I really don't know what to do to solve this. Help!



Reply

PRATEEK JOSHI

May 2, 2019 at 3:54 pm (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-158071)

Hi Pratik,

The article helped me a lot. What should I do if I want to summarize individual articles rather than generating common summary for all the articles.

Reply

PRATEEK JOSHI

May 2, 2019 at 3:54 pm (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-158071)

Hi Neeraj,

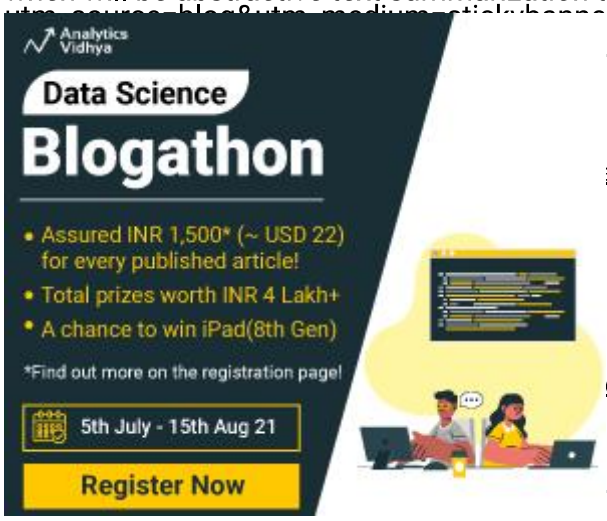
To summarize a single article, you don't have to do anything extra. This code will work.

Thanks!

NEERAJ SHARMA

(https://ascendpro.analyticsvidhya.com/?utm_source=blog&utm_medium=stickybanner1#av-

when will be abstractive text summarization technique discussed?



(https://datahack.analyticsvidhya.com/contest/data-science-blogathon-10/?utm_source=blog&utm_medium=stickybanner2)

Reply

vidhya.com/blog/2019/06/comprehensive-guide-text-

It covers abstractive text summarization in detail.

ESSEN.AI (HTTP://ESSEN.AI) **Reply**

June 20, 2019 at 1:44 am (https://www.analyticsvidhya.com/blog/2018/11/introduction-text-summarization-textrank-python/#comment-158621)

A good post on TextRank

ustering Techniques (Skill test Solution)
017/02/test-data-scientist-clustering/)

sics of Deep Learning (along with solution)
017/01/must-know-questions-deep-learning/)

hms (with Python and R Codes)
017/09/common-machine-learning-algorithms/)

Top 30 MCQs to Ace Your Data Science Interviews (https://www.analyticsvidhya.com/blog/2021/04/top-30-mcqs-to-ace-your-data-science-questions-interviews/)

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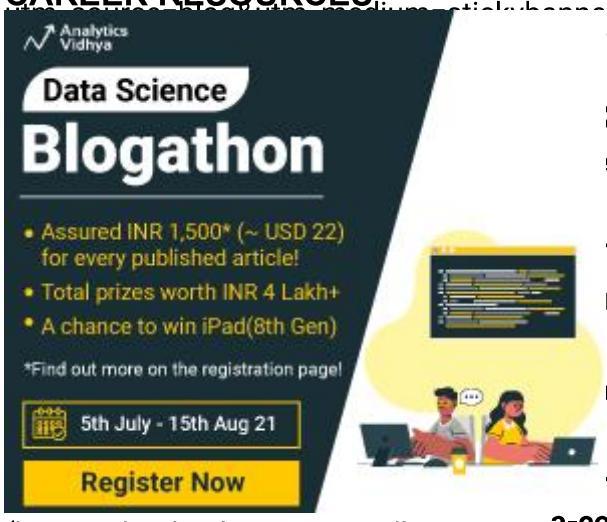
30 Questions to test a data scientist on K-Nearest Neighbors (kNN) Algorithm (https://www.analyticsvidhya.com/blog/2017/09/30-questions-test-k-nearest-neighbors-algorithm/)

CAREER RESOURCES



ey Questions You Should Answer Before Transitioning into Data nce (https://www.analyticsvidhya.com/16-key-questions-data-nce-career-transition/?n_source=Blog&utm_medium=CareerResourceWidget)

EMBER 23, 2020

t is A Business Analyst and What is the Role of a business analyst Company? (https://www.analyticsvidhya.com/blog/2021/06/what--business-analyst-and-what-is-the-role-of-a-business-analyst-in-a-company/?&utm_source=Blog&utm_medium=CareerResourceWidget)

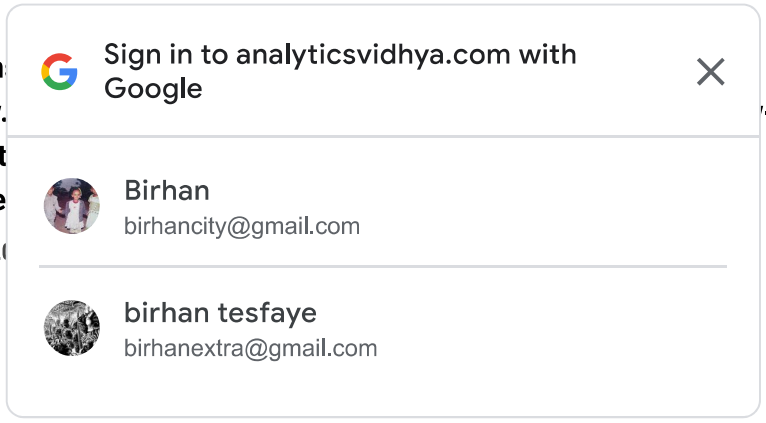
JUNE 28, 2021

Data Engineering – Concepts and Importance (https://www.analyticsvidhya.com/blog/2021/06/data-engineering-concepts-and-importance/?&utm_source=Blog&utm_medium=CareerResourceWidget)

JUNE 14, 2021

Here's What You Need to Know to Become a Data Scientist! (https://www.analyticsvidhya.com/blog/2021/01/heres-what-you-need-to-know-to-become-a-data-scientist/?&utm_source=Blog&utm_medium=CareerResourceWidget)

JANUARY 22, 2021



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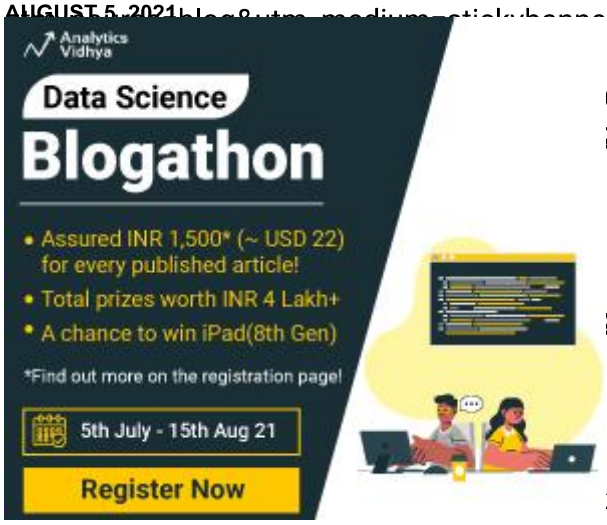
Using NLP! (https://www.analyticsvidhya.com/blog/2021/08/the-
identifying-the-language-using-nlp/)
(https://ascendpro.analyticsvidhya.com/?
AUGUST 5, 2021 blog&utm_medium=stickybanner1#av-



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(https://www.analyticsvidhya.com/blog/2021/08/create-an-interesting-application-filter-like-facebook-with-
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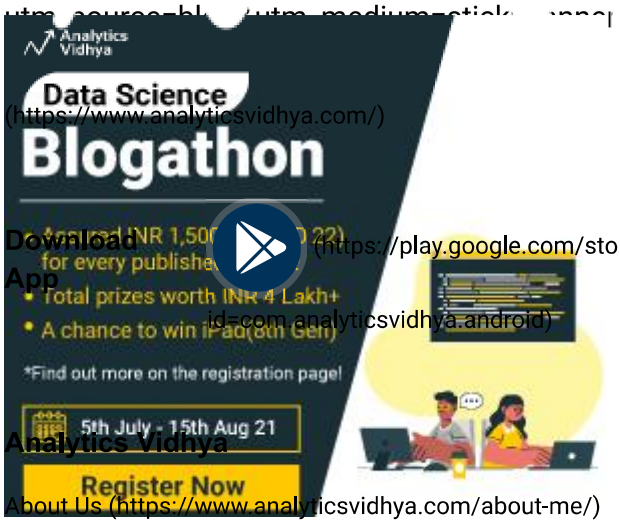

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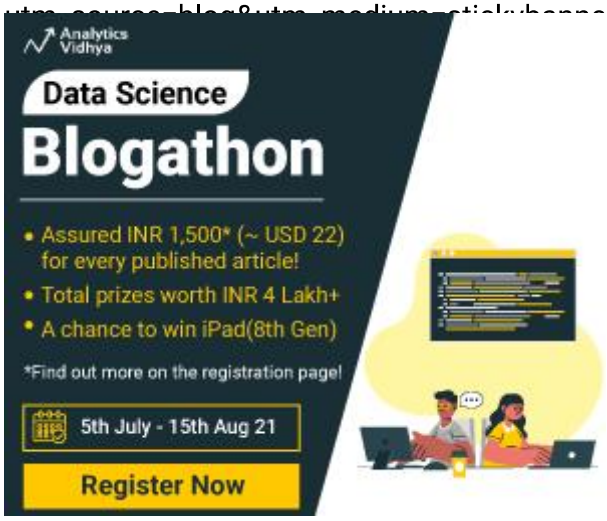

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