

Lecture 17: Computational Efficiency, OnDemand on CRC

LING 1340/2340: Data Science for Linguists

Na-Rae Han

Objectives

- ▶ Big data considerations
 - ◆ Explore on command line
 - ◆ Making Python code more efficient
- ▶ OnDemand platform & JNB at CRC (GUI!)
 - ◆ Clustering, topic modelling

The Yelp Dataset Challenge

▶ <https://www.yelp.com/dataset>

The screenshot shows a web browser window with the URL `yelp.com/dataset/download`. The page features a red header with the Yelp logo and the word "Dataset". Below the header, the main heading is "Download The Data", followed by a warning: "The links to download the data will be valid for 30 seconds." There are two columns of data options. The left column is for "JSON" data, with a "Download JSON" button, and lists "4.04GB compressed" and "8.65GB uncompressed" data, along with "1 .tgz file compressed" and "1 .pdf file and 5 .json files uncompressed". The right column is for "Photos", with a "Download photos" button, and lists "6.93GB compressed" and "7.11GB uncompressed" data, along with "1 .tar file compressed" and "1 .json file, 1 text file, 1 .pdf and 1 folder containing 200,100 photos".

JSON	Photos
Download JSON	Download photos
4.04GB compressed 8.65GB uncompressed	6.93GB compressed 7.11GB uncompressed
1 .tgz file compressed 1 .pdf file and 5 .json files uncompressed	1 .tar file compressed 1 .json file, 1 text file, 1 .pdf and 1 folder containing 200,100 photos

Working with big data files

```
naraehan@login0:/bgfs/ling2340_2023s/shared_data/yelp_dataset
[naraehan@login0 ~]$ cd /bgfs/ling2340_2023s/shared_data/yelp_dataset/
[naraehan@login0 yelp_dataset]$ ls -lh
total 5.5G
-rw-r--r-- 1 naraehan ling2340_2023s 79K Mar 17 2022 Dataset_User_Agreement.pdf
-rw-r--r-- 1 naraehan ling2340_2023s 114M Mar 17 2022 yelp_academic_dataset_business.json
-rw-r--r-- 1 naraehan ling2340_2023s 274M Mar 17 2022 yelp_academic_dataset_checkin.json
-rw-r--r-- 1 naraehan ling2340_2023s 5.0G Mar 17 2022 yelp_academic_dataset_review.json
-rw-r--r-- 1 naraehan ling2340_2023s 173M Mar 17 2022 yelp_academic_dataset_tip.json
-rw-r--r-- 1 naraehan ling2340_2023s 3.2G Mar 17 2022 yelp_academic_dataset_user.json
[naraehan@login0 yelp_dataset]$ wc -l yelp_academic_dataset_review.json
6990280 yelp_academic_dataset_review.json
[naraehan@login0 yelp_dataset]$ wc -l yelp_academic_dataset_user.json
1987897 yelp_academic_dataset_user.json
[naraehan@login0 yelp_dataset]$ |
```

► Each file is in JSON format, and they are huge:

- ◆ review.json is 5.0GB with 7 million records
- ◆ user.json is 3.2GB with 2 million records

← Too big to open in most text editors (Notepad++ couldn't.)

← How to explore them?

In command line. [head/tail](#), [grep](#) and [regular expression](#)-based searching.

Command line exploration: 5-star reviews?

```
MINGW64:/c/Users/Jane Eyre
[naraehan@login0 yelp_dataset]$ head -1 yelp_academic_dataset_review.json
{"review_id":"KU_05udG6zpxOg-VcAEodg","user_id":"mh_-eMZ6K5RLWhZyISBhWA","business_id":"XQfwVwDr-v0ZS3_Cbbe5Xw",
"stars":3.0,"useful":0,"funny":0,"cool":0,"text":"If you decide to eat here, just be aware it is going to take a
bout 2 hours from beginning to end. We have tried it multiple times, because I want to like it! I have been to i
t's other locations in NJ and never had a bad experience. \n\nThe food is good, but it takes a very long time to
come out. The waitstaff is very young, but usually pleasant. We have just had too many experiences where we spe
nt way too long waiting. We usually opt for another diner or restaurant on the weekends, in order to be done qui
cker.","date":"2018-07-07 22:09:11"}
[naraehan@login0 yelp_dataset]$ tail -1 yelp_academic_dataset_review.json
{"review_id":"RwcK0dEuLRHNJe4M9-qpgg","user_id":"6JehEvdoCVZPJ_XIxnzIIw","business_id":"VAeEXLbEcI9Emt9KGYq9aA",
"stars":3.0,"useful":10,"funny":3,"cool":7,"text":"Located in the 'Walking District' in Nashville, it's was a bi
t out of the way for us, but we were on a mission to experience the proclaimed 'Greatest burger in Nashville'. \
\n\nThe menu includes several burgers, wursthen, and chicken sandwich options. The waitress told us that The Farm
Burger is the most popular. I for one have never had a burger with an egg and the thought of it isn't very appe
aling. \n\nI ended up ordering the 'Pharmacy Burger', which is a less cheesier version of their 'Cheese Burger'
that my husband ordered. They LOADED the mustard, but that really wasn't what I didn't like about it. It really
wasn't that I disliked the burger, it just wasn't anywhere near one of the best burgers that I've had. The extra
toppings at fifty cents each are pretty skimpy too. I was a fan of the wasabi aioli though. I also loved the ta
ter tots though. I highly recommend ordering tater tots over the french fries. The beer cheese dipping sauce was
an extra dollar and was borderline disgusting. Stick with wasabi aioli. \n\nI'm thinking that the toppings and
sauces are possibly what the hype about this place is, otherwise, I just don't get it. To describe this place in
one word... overhyped.","date":"2018-01-02 22:50:47"}
[naraehan@login0 yelp_dataset]$ grep "stars.:5.0" yelp_academic_dataset_review.json | head -3
{"review_id":"BiTunyQ73aT9WBnpR9DZGw","user_id":"OyoGAe70Kpv6SyGZT5g77Q","business_id":"M3jU1t4UM3IypQ",
"stars":5.0,"useful":1,"funny":0,"cool":1,"text":"I've taken a lot of sp...s, and nothing c
omparates to the classes at Body Cycle. From the nice, clean space and ama...ing and motivat
ing instructors, every class is a top notch work out.\n\nFor anyone who...s in, the online
scheduling system makes it easy to plan ahead (and there's no need to line up way in advanced like many gyms ma
ke you do).\n\nThere is no way I can write this review without giving Russell, the owner of Body Cycle, a shout
out. Russell's passion for fitness and cycling is so evident, as is his desire for all of his clients to succeed
. He is always dropping in to classes to check in\provide encouragement, and is open to ideas and recommendatio
ns from anyone. Russell always wears a smile on his face, even when he's kicking your butt in class!","date":"20
12-01-03 15:28:18"}
```

Grepping 5-star reviews

Command line exploration: 'yummy' vs. 'horrible'

```
naraehan@login1:~  
[naraehan@login1 ~]$ ls -lh *.json  
-rw-r--r-- 1 naraehan nhan 7.4M Mar 29 07:58 review_10k.json  
-rw-r--r-- 1 naraehan nhan 735K Mar 29 07:59 review_1k.json  
-rw-r--r-- 1 naraehan nhan 729M Mar 27 10:27 review_1mil.json  
[naraehan@login1 ~]$ grep -i 'yummy' review_1mil.json | head -1  
{"review_id":"DE5-X9lghfs6wvzwZCrpeQ","user_id":"ZtQr5D0hdD0yCJxa16oqlQ","business_id":"_OMGZ2By7skat_bw","stars":5.0,"useful":0,"funny":0,"cool":0,"text":"I always go to the Newbold location . Cool chill spot with BEER ! And yummy tea and croissant . Staff are very nice . I prefer it when it isn't wildly busy . The owners are very nice and I highly recommend this spot if you just want to chillax alone or have a nice convo with someone . Not a crowd spot so please youngsters , keep away !! :)", "date":"2016-02-24 20:00:56"}  
[naraehan@login1 ~]$ grep -i 'yummy' review_1mil.json | wc -l  
18890  
[naraehan@login1 ~]$ grep -i 'horrible' review_1mil.json | head -1  
{"review_id":"x-Xd94pUXrjxucg7dd2Ecw","user_id":"kaoGNhDrb_YTcRj_zJPDag","business_id":"_OMGZ2By7skat_bw","stars":1.0,"useful":8,"funny":4,"cool":1,"text":"I don't like talking crap about the place, but I had a horrible experience... \nMy B.F and I went here to have Sushi and celebrate the start of our new life in STL. I don't remember what day it was, but I believe it was a weekda the place was empty. The hostess sat us on 2 seaters table on the very end of 2nd Fl. Sushi w AY overpriced for what we get and techno music was so loud , but it was our happy day, so we k until.....\nThen, the hostess sat 2 college gals RIGHT NEXT TO US. HELLOWWW?! The place is EMPTY!!! why don't you at least skip one table b/w us and them?! Of course these too girls are like \"Oh my GOD, I totally love this place oh, you should totally try this roll! Tthis is totally miso and totally blah blah blah blah\". They were even louder than the techno music.\n\nSTL has so many gre at places with courtesy. You can not only try to be hip and cool without any efforrt. The waiter wa s a nice guy, but the hostess was an idiot. \n\nI was just so disappointed. We'll never go back to this place.", "date":"2010-03-05 13:51:17"}  
[naraehan@login1 ~]$ grep -i 'horrible' review_1mil.json | wc -l  
19912  
[naraehan@login1 ~]$ |
```

Change of venue!
Let's work with the 1mil
sampled reviews. Big enough,
more manageable.

How many of 1 million
reviews mention
'yummy'? How about
'horrible'?

A quick look at "Stars" distribution

```
naraehan@login1:~  
[naraehan@login1 ~]$ head -1 review_1mil.json  
{  
  "review_id": "KM0140axZz00htZ3gbrEIw",  
  "user_id": "TFONZw2s_kB15GfCtNLkiA",  
  "business_id": "bND1b-AEPAOmPLpUK7dJWQ",  
  "stars": 5.0,  
  "useful": 0,  
  "funny": 0,  
  "cool": 0,  
  "text": "went here for dinner the other night . I tried the egg rolls and the bulgogi don. The bulgogi don was really delicious! The meat was tasty and the rice cooked well. The egg roll appetizer was nice and crunchy.",  
  "date": "2017-05-10 13:48:07"  
}  
[naraehan@login1 ~]$ cat review_1mil.json | cut -d, -f4 | head -10  
"stars":5.0  
"stars":4.0  
"stars":5.0  
"stars":1.0  
"stars":5.0  
"stars":1.0  
"stars":5.0  
"stars":3.0  
"stars":5.0  
"stars":5.0  
[naraehan@login1 ~]$ cat review_1mil.json | cut -d, -f4 | head -10 | sort  
"stars":1.0  
"stars":1.0  
"stars":3.0  
"stars":4.0  
"stars":5.0  
"stars":5.0  
"stars":5.0  
"stars":5.0  
"stars":5.0  
"stars":5.0  
[naraehan@login1 ~]$ cat review_1mil.json | cut -d, -f4 | head -10 | sort | uniq -c  
  2 "stars":1.0  
  1 "stars":3.0  
  1 "stars":4.0  
  6 "stars":5.0  
[naraehan@login1 ~]$
```

Cut the 4th field with "," as the delimiter, then look at the first 10.

... then sort the lines...

... then collapse adjacent identical lines with a count!

Which "Stars" most common? With 'horrible'?

```
MINGW64:/c/Users/Jane Eyre
notes.txt      review_10k.json  tidy_2022/     working/
[naraehan@login0 ~]$ cat review_10k.json | cut -d, -f4 | sort | uniq -c
152924 "stars":1.0
 78299 "stars":2.0
 99454 "stars":3.0
207216 "stars":4.0
462107 "stars":5.0
[naraehan@login0 ~]$ cat review_1mil.json | grep -i 'horrible' | cut -d, -f4 | sort | uniq -c
13932 "stars":1.0
 2831 "stars":2.0
 1405 "stars":3.0
  752 "stars":4.0
  992 "stars":5.0
[naraehan@login0 ~]$ cat review_1mil.json | grep -i 'horrible' | grep 'stars.:5.0' | head
{"review_id":"xI01K9l6b2VwQFB2awA2Mw","user_id":"jkkwp10shJNxp3sTnl0aTg","business_id":"6XOTisJ49USEiPk8rSwtNw",
"stars":5.0,"useful":4,"funny":1,"cool":1,"text":"My sewer backed up Memorial day weekend. I needed a clog removed, so I looked online and
ner myself, I know you have to provide excellent service to be rewarded with such great customer reviews. The re
views didn't lie. Tom was here quicker than expected, assessed and resolved the problem quickly and at his norm
al rate. Many companies would have a \"weekend\" or \"after hours\" rate. Tom is an honest, respectful guy and r
eally knows his business. I would and will recommend him to anyone I know who needs his services. Thank you Tom
for resolving a horrible situation in quick order.", "date":"2016-05-31 01:14:06"}
{"review_id":"Cha6M6XUDPfdhwLsi7kPIA","user_id":"H_8dbiu8GweYYnmEPR-6_g","business_id":"C6glRVRajUc-QGrSzhurAw",
"stars":5.0,"useful":1,"funny":0,"cool":0,"text":"After a horrible experience at another local dentist I'm so ha
ppy I found this place. Thank you to Ariel for taking such good care of me today. These guys really care about t
he work they're doing and it shows. The staff are friendly, professional, and the quality of work is outstanding
. When asking about other services like Invisalign, they explained costs, financing options, and length of treat
ment without being pushy. Overall, this place is fantastic. I am looking forward to my next 6 month cleaning!","
date":"2017-07-26 20:19:35"}
{"review_id":"AqsMqUGo7V0piQQ6hbZyxQ","user_id":"gz9sv7NCg7Qe2awt2X_OmA","business_id":"4JWuSA8tyXHteRgh_hU_Cw",
"stars":5.0,"useful":0,"funny":0,"cool":0,"text":"My daughter and I spent 4 days in the French Quarter just prio
r to Mardi Gras 2020. This was my 3rd visit and her first. Last year when my sisters and I visited we stayed at
the French Market Inn. We had such a positive time staying at this hotel. Wonderful southern hospitality and the
```

Now try the whole 1million reviews.
1-star reviews are 3rd most common!

What if "horrible" is mentioned?

"horrible" and... 5 stars??

Opening + processing big files

- ▶ How much resource does it take to process review.json file (5.0GB)?

```
process_reviews.py - D:/Corpora/Yelp_dataset_2023/process_reviews.py (3.9.7)
File Edit Format Run Options Window Help
import pandas as pd
import sys
from collections import Counter

filename = sys.argv[1]

df = pd.read_json(filename, lines=True, encoding='utf-8')

print(df.head(5))

wtoks = ' '.join(df['text']).split()
wfreq = Counter(wtoks)

print(wfreq.most_common(20))
```

There's 5 GB

Another 4~ GB

Not as big

This code is NOT memory-efficient.

Exceeds the 4GB default memory allocation on CRC.

When run on your own laptop, script will likely crash citing "MemoryError"

Big objects: avoid creating, manually delete

- ▶ Try avoiding making big data objects in the first place.
- ▶ Manually free up memory by deleting objects when done using. (Advanced users only!)

```
process_reviews.py - D:/Corpora/Yelp_dataset_2023/process_reviews.py (3.9.7)
File Edit Format Run Options Window Help
import pandas as pd
import sys
from collections import Counter

filename = sys.argv[1]

df = pd.read_json(filename, lines=True, encoding='utf-8')

print(df.head(5))

wtoks = ' '.join(df['text']).split()
wfreq = Counter(wtoks)

print(wfreq.most_common(20))
```

Rather than creating `wtoks` AND `wfreq`, you could:
`wfreq = Counter(' '.join(df['text']).split())`

If you no longer need `df`, delete it:
`del df`
`gc.collect()`

Garbage collection:
Python takes care of some memory management on its own.

Memory consideration

- ▶ How much space needed for bigrams? Trigrams?

Good news! These are built as *generator objects* and take up almost zero space.

```
process_reviews2.py - D:/Corpora/Yelp_dataset_2023/process_reviews2.py (3.9.7)
File Edit Format Run Options Window Help
import pandas as pd
import sys
from collections import Counter

filename = sys.argv[1]

df = pd.read_json(filename, lines=True, encoding='utf-8')

print(df.head(5))

wtoks = ' '.join(df['text']).split()
bigrams = nltk.bigrams(wtoks)
trigrams = nltk.trigrams(wtoks)

bifreq = Counter(bigrams)
print(bifreq.most_common(20))

trifreq = Counter(trigrams)
print(trifreq.most_common(20))
```

But these frequency counter objects will take up space.

Generator type objects take up little memory space; meant to be used in a loop-like environment.

Content has been exhausted

```
>>> import nltk
>>> sent = 'Colorless green ideas sleep oh so very furiously'
>>> toks = sent.split()
>>> toks
['Colorless', 'green', 'ideas', 'sleep', 'oh', 'so', 'very', 'furiously']
>>> bigrams = nltk.bigrams(toks)
>>> bigrams
<generator object bigrams at 0x00000236371E2BF8>
>>> for b in bigrams:
    print(b)

('Colorless', 'green')
('green', 'ideas')
('ideas', 'sleep')
('sleep', 'oh')
('oh', 'so')
('so', 'very')
('very', 'furiously')
>>> bigrams
<generator object bigrams at 0x00000236371E2BF8>
>>> list(bigrams)
[]
>>> bigrams = nltk.bigrams(toks)
>>> list(bigrams)
[('Colorless', 'green'), ('green', 'ideas'), ('ideas', 'sleep'), ('sleep', 'oh'), ('oh', 'so'), ('so', 'very'), ('very', 'furiously')]
>>>
```

Casting as list.
If you store the returned list, it will take up memory space.

File opening & closing methods

```
f = open('review.json')
lines = f.readlines()
for l in lines:
    if 'horrible' in l:
        print(l)
f.close()
```

```
lines = open('review.json').readlines()
for l in lines :
    if 'horrible' in l:
        print(l)
```

Python will close up this file handle.

Which methods are memory-efficient?

```
f = open('review.json')
for l in f:
    if 'horrible' in l:
        print(l)
f.close()
```

```
with open('review.json') as f:
    for l in f:
        if 'horrible' in l:
            print(l)
```

No need to close f later. Some folks swear by using `with`.

Handling files in chunks

```
f = open('review.json')
lines1 = f.readlines(1000000000)
lines2 = f.readlines(1000000000)
lines3 = f.readlines(1000000000)
lines4 = f.readlines(1000000000)
lines5 = f.readlines()
f.close()
```

Optional # of bytes to read.
(When used like this without a loop, offers no memory advantage.)

```
dfs = pd.read_json('review.json', lines=True, chunksize=10000, encoding='utf8')
wfreq = Counter()

for df in dfs:
    wtoks = ' '.join(df['text']).split()
    temp = Counter(wtoks)
    wfreq.update(temp)

print(wfreq.most_common(20))
```

Generator object. Takes up zero space.

`chunksize` optional parameter in pandas' `read_json` method reads in 10,000 lines at a time...

then, iterate through each small `df`.

Memory-efficient!
This code uses only **290MB** of memory!!

Pandas vs. large data: tips

- ▶ "Why and How to Use Pandas with Large (but not big) Data"
 - ◆ <https://towardsdatascience.com/why-and-how-to-use-pandas-with-large-data-9594dda2ea4c>
- 1. Read CSV file data in chunk size
- 2. Filter out unimportant columns in DF to save memory
- 3. Change dtypes for columns
 - ◆ float64 takes up more space than float32.

Vectorizing and training in chunks

```
from sklearn.naive_bayes import MultinomialNB
from sklearn.feature_extraction.text import HashingVectorizer
import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)

filename = 'review_10k.json'
length = 10000
chunk_size = 1000
chunks = length/chunk_size

df_chunks = pd.read_json(filename, lines=True, chunksize=chunk_size, encoding="utf-8")

clf = MultinomialNB()
vectorizer = HashingVectorizer(alternate_sign=False)

for i, df in enumerate(df_chunks):
    if i < 0.8 * chunks:
        clf.partial_fit(vectorizer.transform(df['text']), df['stars'], classes=[1,2,3,4,5])
    else:
        pred = clf.predict(vectorizer.transform(df['text']))
        print('batch {}, {} accuracy'.format(i, np.mean(pred == df['stars'])))
```

If vectorizer/ML model depends only on individual row of data, it can be implemented in chunks.
(Caveat: TF-IDF vectorizer and most ML models can't.)

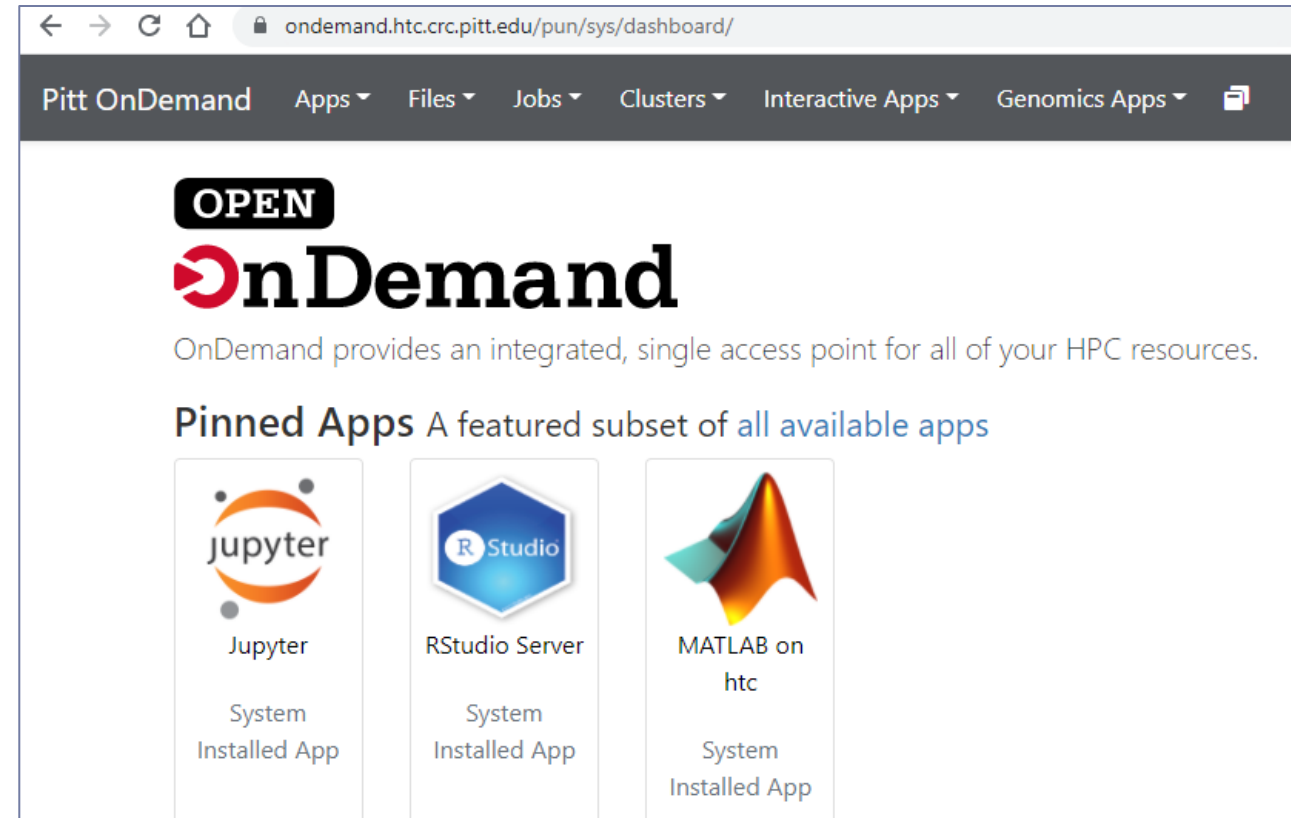
Hashing vectorizer skips the IDF part of TF/IDF, can be implemented in chunks!

NB classifier can be trained in partial bits!

```
batch 8, 0.444 accuracy
batch 9, 0.439 accuracy
```

OnDemand on CRC!

- ▶ Browser-based gateway to CRC resources!
 - ◆ <https://ondemand.htc.crc.pitt.edu/>
- ▶ Jupyter Notebook (Lab) etc. are available!
- ▶ Help documentation is somewhat buried:
 - ◆ <https://crc.pitt.edu/resources/htc-cluster/open-ondemand>



Launching a session

- ▶ Python version: `module load python/ondemand-jupyter-python3.9`
- ▶ Account: `ling2340_2023s`

Python version

`module load python/ondemand-jupyter-python3.9` ▼

Account

`ling2340_2023s`

- The allocation you would like to use for SLURM.

Jupyter (663715)

1 node | 1 core | Running

Host: >_htc-n16.crc.pitt.edu

Delete

Created at: 2022-03-31 14:11:10 EDT

Time Remaining: 59 minutes

Session ID: 4f790652-695e-4043-9e38-27d4b9ace746

Connect to Jupyter

ondemand.htc.crc.pitt.edu/node/htc-n16.crc.pitt.edu/3445/lab

File Edit View Run Kernel Tabs Settings Help

Filter files by name

Name	Last Modified
ets	a year ago
multicore	a year ago
old	a year ago
ondemand	a year ago
pyling	4 years ago
shared_data	a year ago
tidy	2 days ago
vault	3 years ago
w2v	3 years ago
working	a year ago
yelp_datase...	2 days ago
clustering.i...	11 minutes ago
hello.out	15 hours ago
hello.sh	15 hours ago
process_rev...	a year ago
review_1k.js...	2 days ago
todo12.sh	2 days ago

Python 3

Launch Python3 Jupyter Notebook

Python 3

Console

Python 3

Other

Terminal

Text File

Markdown File

Show Contextual Help

Content of my CRC home folder

Wrap up

- ▶ Homework #4 out – don't be too ambitious!
- ▶ Progress report #3, presentation up coming!