

The image shows the Ecce - Bible Explorer application running on both a desktop browser and a mobile phone. The desktop view features a dark blue header with the 'Ecce' logo and 'BETA' status, followed by 'VERSES', 'TOPICS', and 'ABOUT' links. Below this is a light green main area titled 'Bible Text AI'. It contains a search bar with placeholder text 'Enter part of a verse or a phrase we'll try to find related Biblical topics and passages' and a yellow 'Find' button. A note below the search bar says 'e.g. "What is man that you are mindful of him?" or "Why is there evil in the world?"'. To the left is a 'Topics' section with a table showing various topics and their verse counts:

Topics	Passages
JESUS, THE CHRIST	10151 verses
GOD	6512 verses
ISRAEL	4593 verses
ISRAEL, PROPHECIES CONCERNING	4084 verses
PSALMS	3383 verses
DAVID	2986 verses
MINISTER, Christian	2780 verses
CHURCH	2319 verses

To the right is a 'Passages' section listing several biblical references with their first few words:

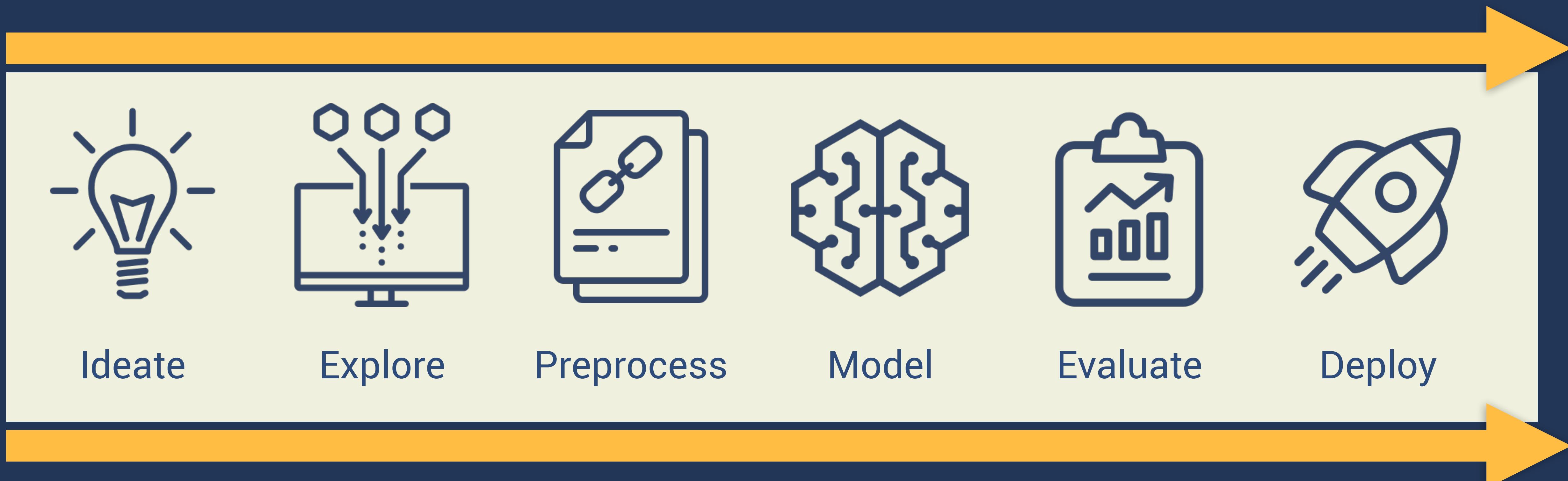
- Genesis 1:1
- Psalms 23:1-6
- Jeremiah 29:11
- Matthew 28:19
- John 3:16
- Romans 8:28
- Romans 12:1
- Galatians 5:22

The mobile phone screen displays the same interface, with the search bar containing 'What is man that you are mindful of him?' and the 'Find' button. Below the search bar are sections for 'Topics' and 'Linked Passage Themes', each with a grid of buttons for categories like 'JOB', 'MAN', 'PRAISE', etc.

Ecce

ML Prediction of Bible Topics and Passages

Data Science Flow





Ideate

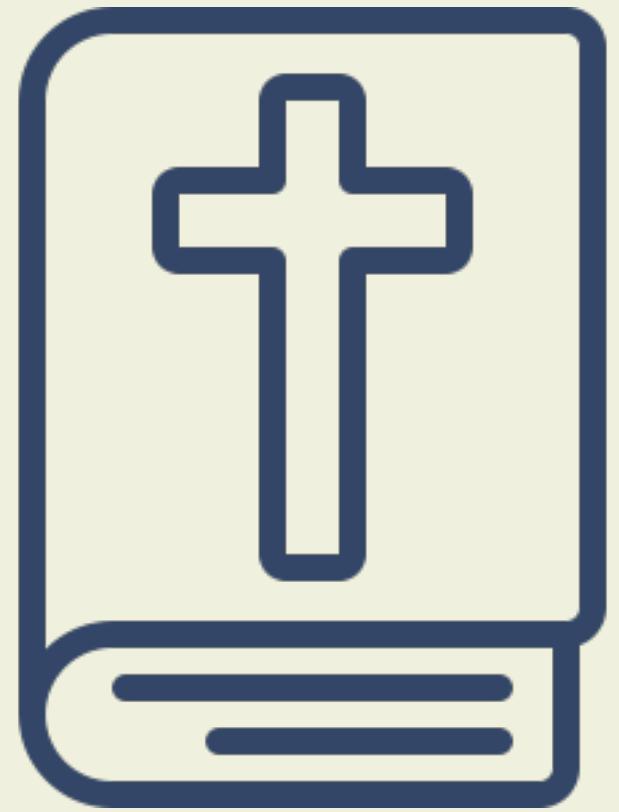




- **Employ** Deep Learning for text analysis
- **Experiment** with sequence-based neural net architectures
- **Explore** Biblical text sources with a data-driven approach
- **Establish** a machine learning tool for Biblical discovery
- **Engage** custom visualization frameworks for exploratory data analysis



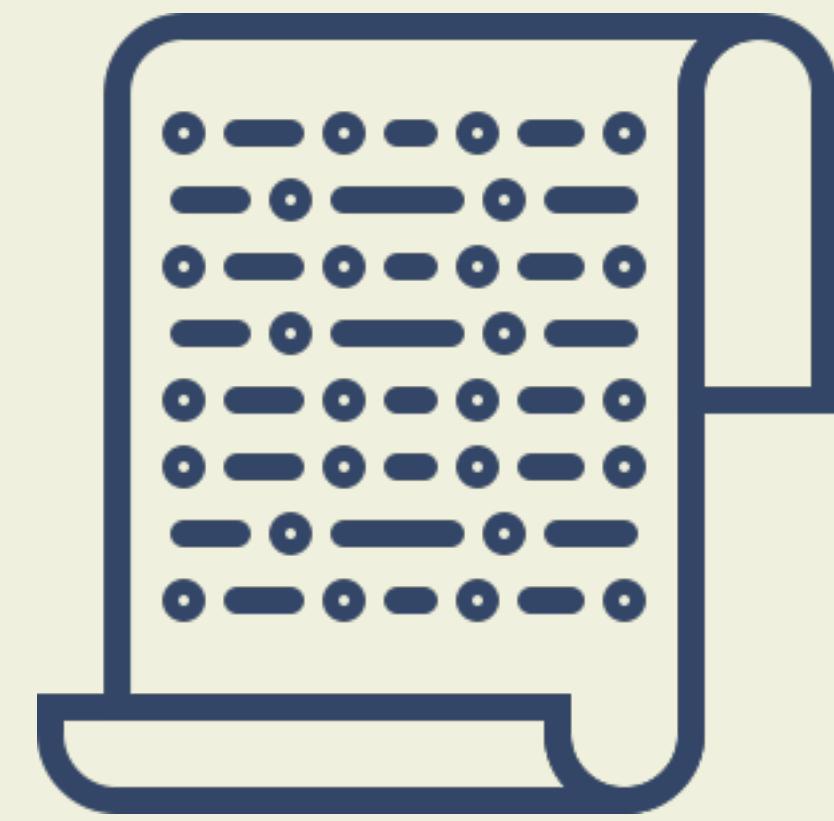
Data Sources



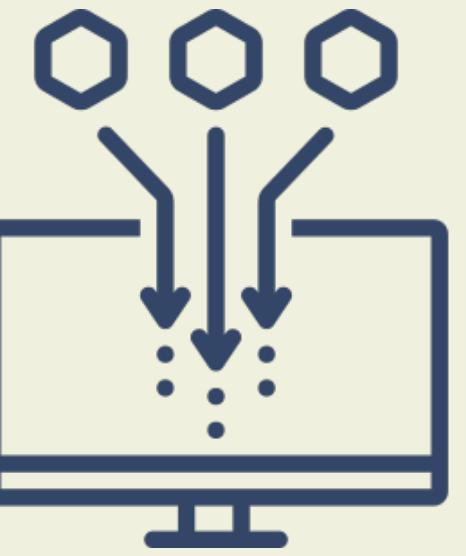
English Standard
Version
(ESV)



Nave's Topical
Index
(Nave)

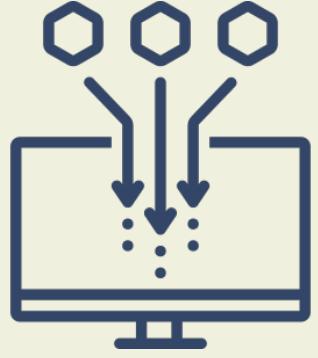


Treasury of
Scripture Knowledge
(TSK)

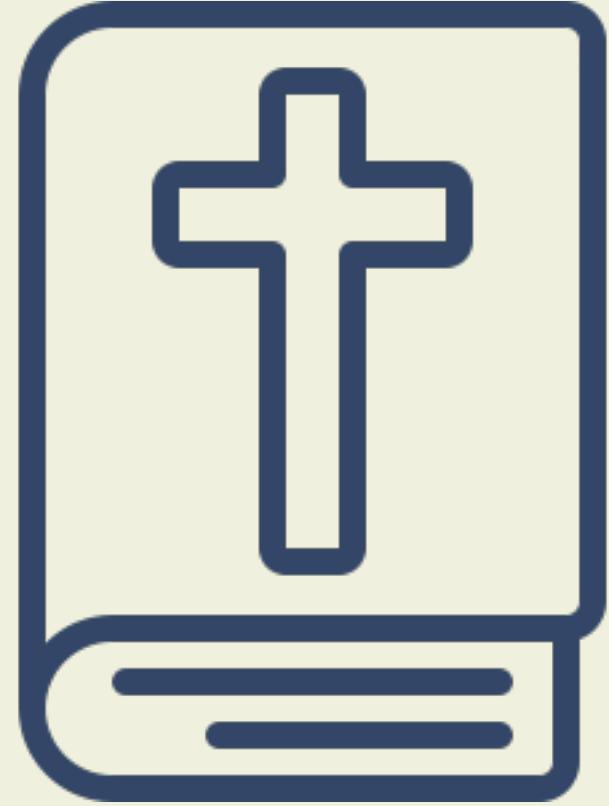


Explore



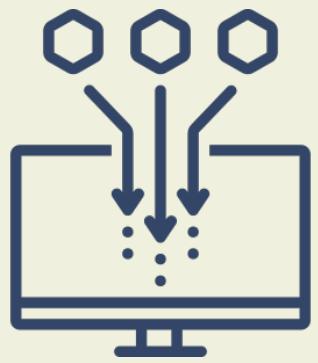


Explore



English Standard
Version

```
{  
    "Genesis": {  
        "1": {  
            "1": "In the beginning, God created the  
                  heavens and the earth.",  
            "2": "The earth was without form and  
                  void, and darkness...",  
            ...  
        }  
        "Judges": {  
            "1": {  
                "1": "After the death of Joshua, the people  
                      of Israel inquired of the Lord...",  
                "2": "...",  
                ...  
            }  
        }  
    }  
}
```

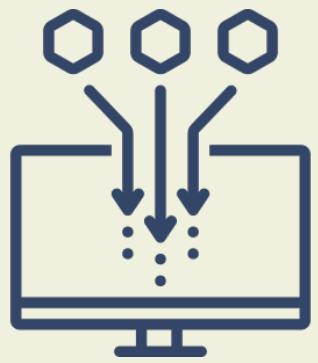


Explore



Nave's Topical
Index

topic key	topic_name	category key	category_text	subtopic text	reference list	sort order category
-2146356859	DANCING	-2108238392	Herodias dances in the presence of Herod (Anti...	General reference(s) to this category	Mt14:6; Mr6:22	2
-2146356859	CORMORANT	696243684	A bird forbidden as food	General reference(s) to this category	Le11:17; De14:17; Isa34:11; Zep2:14	1
-2145523250	CANDACE	1308325410	Queen of Ethiopia	General reference(s) to this category	Ac8:27	1



Explore



Nave's Topical Index

Ecce^{BETA}

VERSES TOPICS ABOUT

Explore Verses

Genesis | 1

Genesis 1:1

In the beginning, God created the heavens and the earth.

- [TIME](#), Beginning of, General reference(s) to this category
- [GOD](#), CREATOR, General reference(s) to this category
- [MIRACLES](#), CATALOGUE OF, Creation of the physical world
- [CREATION](#), History of, General reference(s) to this category
- [CREATION](#), Beginning of, General reference(s) to this category
- [JESUS, THE CHRIST](#), UNCLASSIFIED SCRIPTURES RELATING TO HIS MESSIAHSHIP
- [THE DIVINITY OF](#), General reference(s) to this category
- [HEAVEN](#), PHYSICAL HEAVENS, CREATION OF, General reference(s) to this category
- [HEAVEN](#), THE PHYSICAL HEAVENS, General reference(s) to this category
- [EARTH](#), CREATED BY GOD, General reference(s) to this category

Eng...
Topics and categories from Nave's Topical Index

Ecce^{BETA}

VERSES TOPICS ABOUT

[GitHub](#) [LinkedIn](#) [Twitter](#)

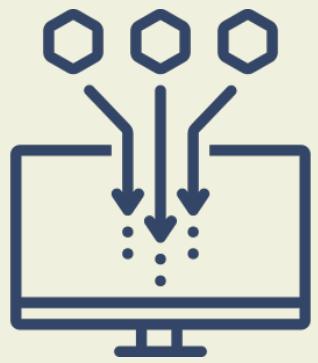
HEAVEN

Passages

JESUS, THE CHRIST (10151 verses)

Genesis 1:1
Genesis 2:1
Deuteronomy 26:15
1 Kings 8:30 39 43 49

MISCELLANEOUS
PROPHECIES CONCERNING THE
MESSIAH
ONIPRESENCE OF
KINGDOM OF
MISSION OF
PARABLES OF
ROPHECIES CONCERNING THE COMING OF
TEMPTATION OF
SUFFERINGS OF
EXALTATION OF
ER SCRIPTURES RELATING TO HIS MESSIAHSHIP
DESIGN OF HIS DEATH
RELATION OF, TO THE FATHER
ASCENSION OF
RESURRECTION OF
SON OF GOD
HISTORY OF
OPHECIES CONCERNING UNIVERSALITY OF THE KINGDOM OF
SECULAR NOTIONS CONCERNING THE KINGDOM OF
CLASSIFIED PROPHECIES CONCERNING THE KINGDOM OF
UNCLASSIFIED PROPHECIES RELATING TO THE DIVINITY OF



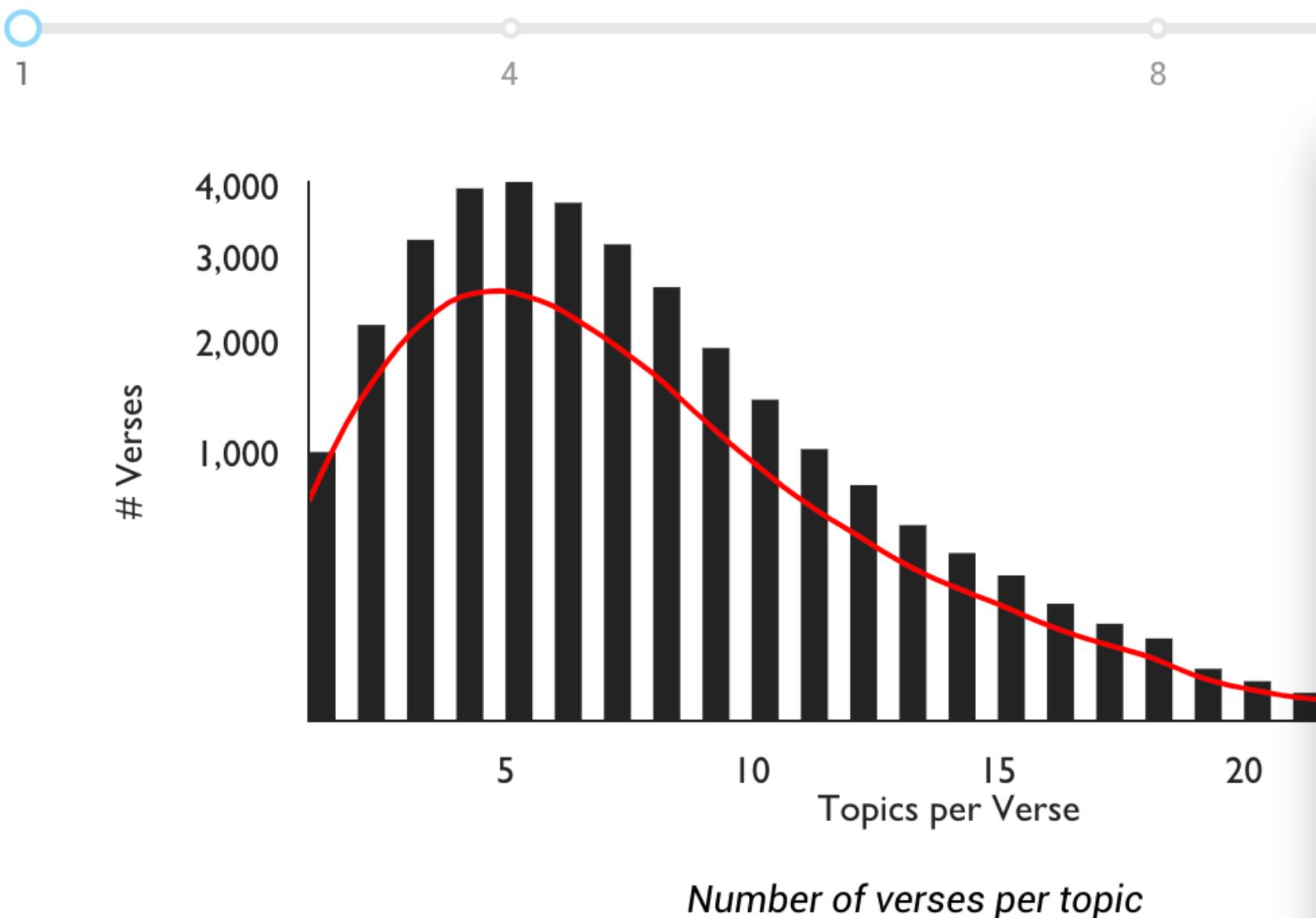
Explore



Nave's Topical
Index

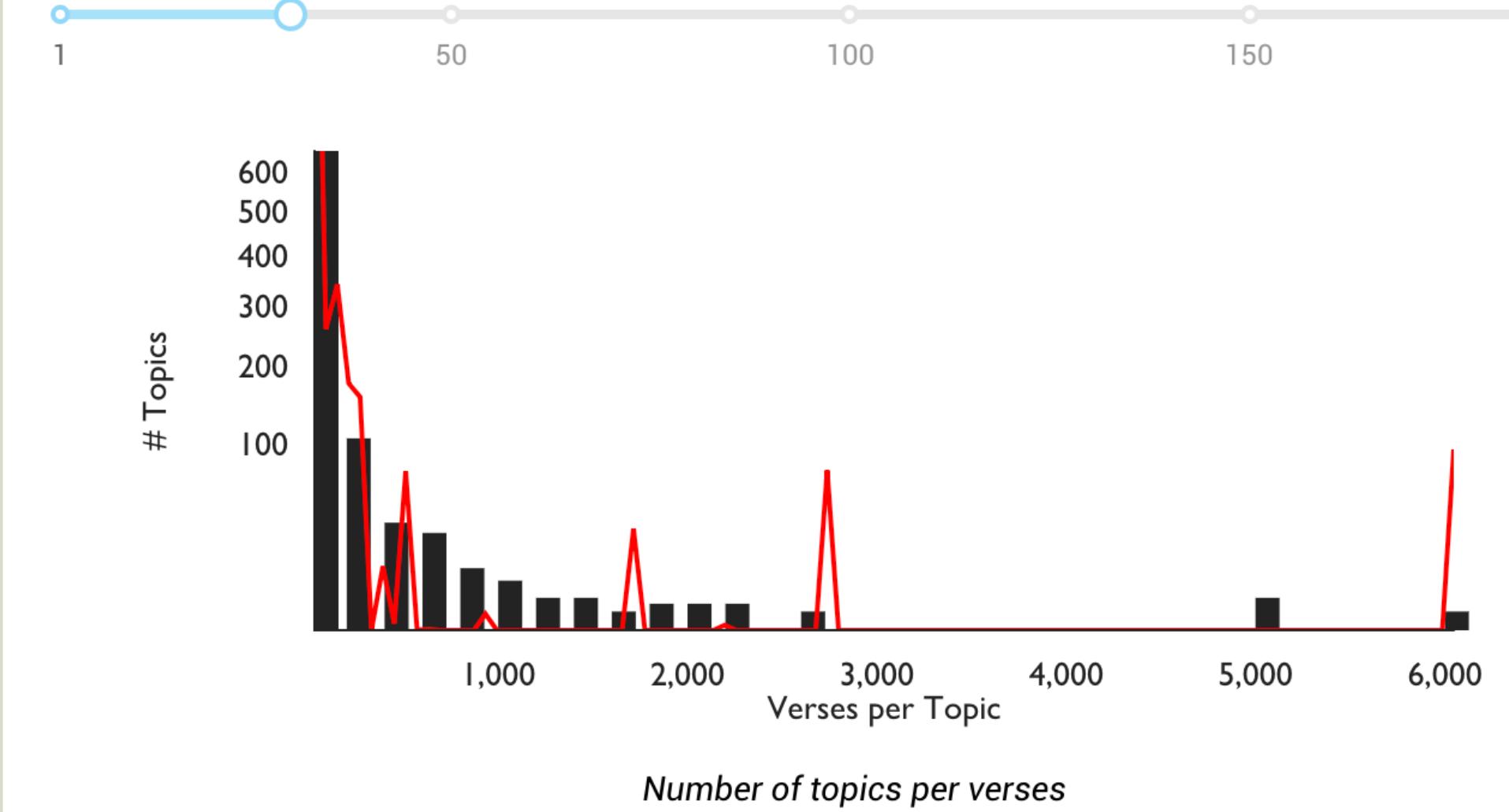
Topic Count by Verse

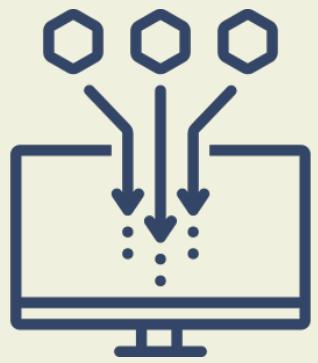
Filtering verses with at least 1 topics (30969 of 30969 verses)



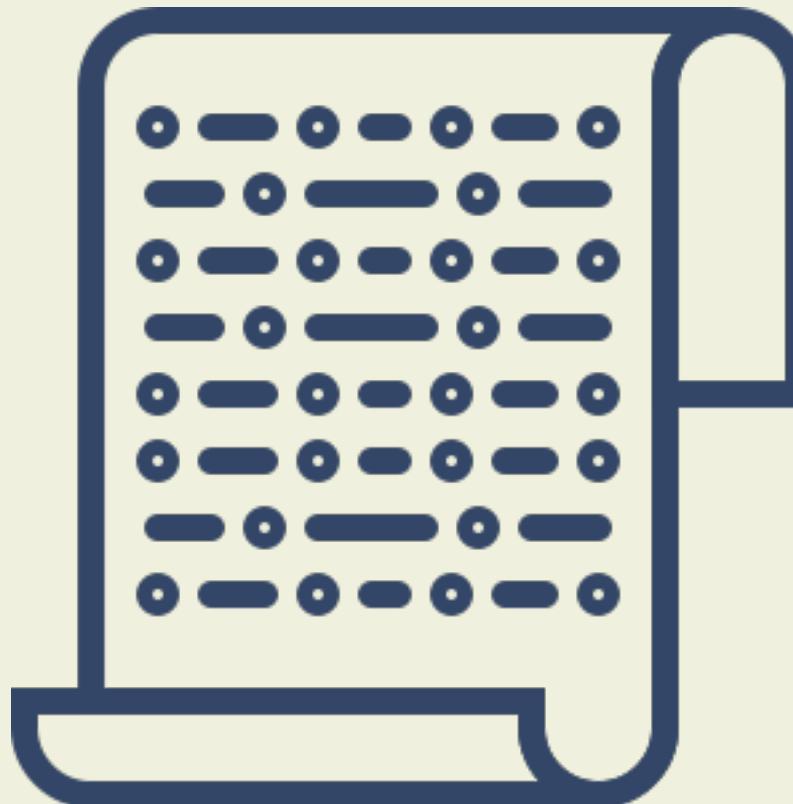
Verse Count by Topic

Filtering topics with at least 30 verses (856 of 4398 topics)





Explore



Treasury of
Scripture Knowledge

book	chapter	verse	sort_order	phrase	reference_list
Genesis	1	1	2	beginning	pr 8:22-24;pr 16:4;mr 13:19;joh 1:1-3...
Genesis	1	1	3	God	ex 20:11;ex 31:18;1ch 16:26;ne 9:6...
Genesis	1	2	1	without	job 26:7;isa 45:18;jer 4:23;na 2:10
Genesis	1	2	2	Spirit	job 26:14;ps 33:6;ps 104:30;isa 40:12-14
Genesis	1	3	1	God	ps 33:6,9;ps 148:5;mt 8:3;joh 11:43



Preprocess



Preprocess

- **Link** topics and categories from Nave
- **Parse** and link reference types from Nave and TSK
- **Retrieve** topics for a specific verse; retrieve verses from a specific topic
- **List** all cross-references for a specific verse
- **Export** (or cache) results for modeling phase



Preprocess



Nave's Topical
Index

book	chapter	verse	topics	text
1 Corinthians	3	18	[PRIDE, HUMILITY, WISDOM, PARADOX]	Let no one deceive himself. If anyone among yo...
1 Corinthians	3	19	[QUOTATIONS, ALLUSIONS, WISDOM, IGNORANCE]	For the wisdom of this world is folly with God...
1 Corinthians	3	20	[WISDOM, ALLUSIONS, QUOTATIONS, VANITY, GOD, H...	and again, "The Lord knows the thoughts of the...
1 Corinthians	3	21	[CONFIDENCE, Christian, RIGHTEOUS, DEATH, MINI...	So let no one boast in men. For all things are...



Preprocess



Nave's Topical
Index

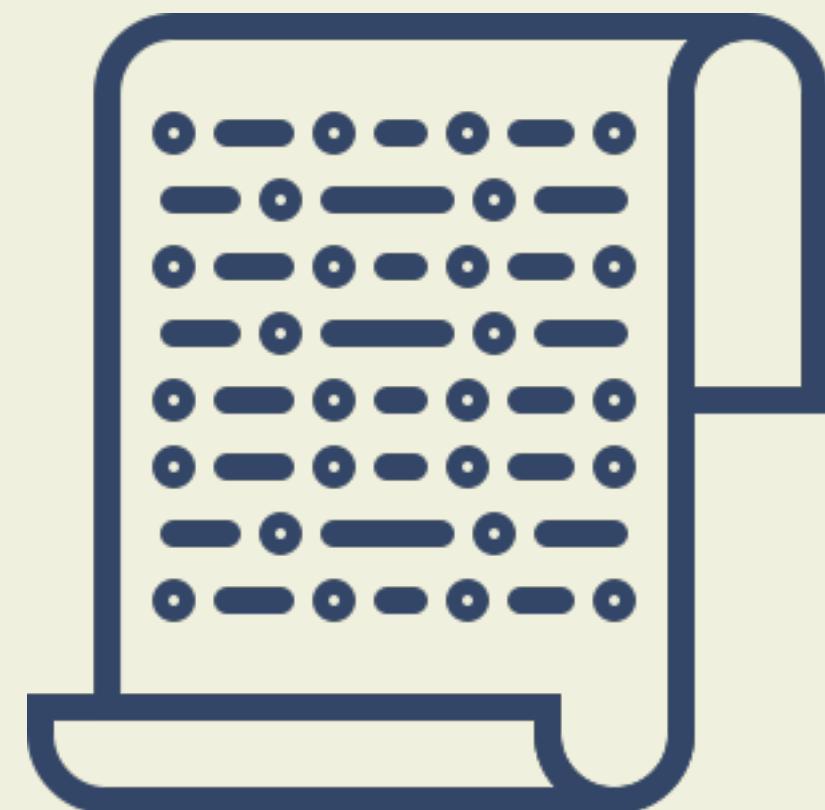
topic_name	verse_count
GOD	6047
JESUS	5069
THE CHRIST	5069
ISRAEL	5008
PSALMS	2738
DAVID	2336
MINISTER	2220
CHURCH	2198
Christian	2155

verse	topic_count
Matthew 27:24	27
Matthew 27:5	27
Acts 26:18	27
Nehemiah 8:7	26
2 Chronicles 17:8	26
Nehemiah 8:4	26
Matthew 27:4	26
Matthew 27:3	25
2 Kings 19:37	24



Preprocess

› `tsk.find_by_uuid('93a9c7b7')`

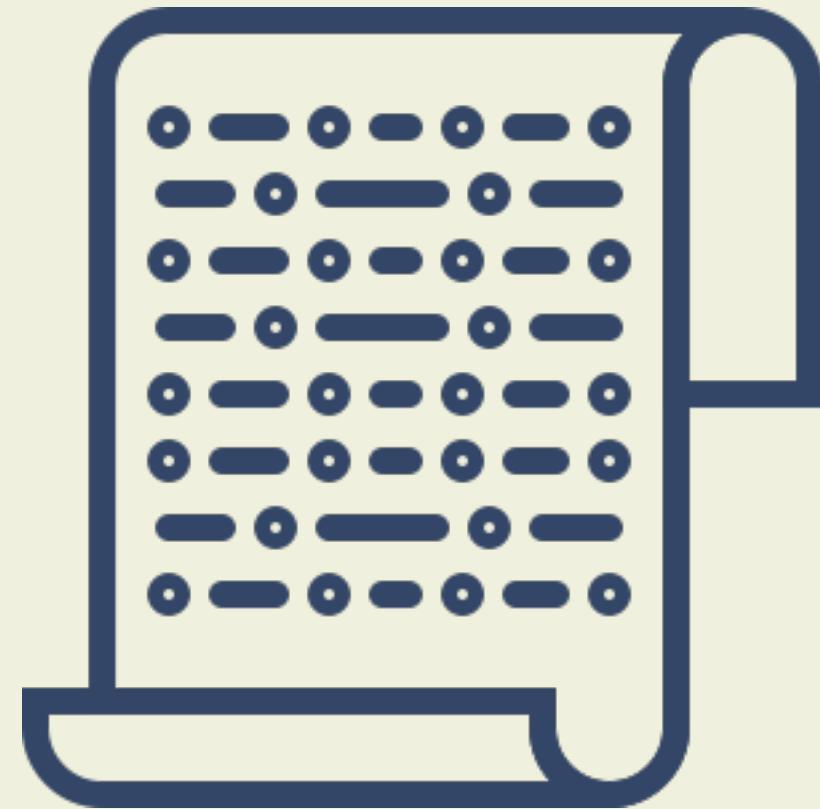


Treasury of
Scripture Knowledge

uuid	linked_book	linked_chapter	linked_verse	phrase	book	chapter	verse
93a9c7b7	Genesis	1	5	Day, and	Genesis	8	22
93a9c7b7	Genesis	1	5	Day, and	Psalms	19	2
93a9c7b7	Genesis	1	5	Day, and	Psalms	74	16
93a9c7b7	Genesis	1	5	Day, and	Psalms	104	20
93a9c7b7	Genesis	1	5	Day, and	Isaiah	45	7



Preprocess



Treasury of
Scripture Knowledge

```
> tsk.passages_by_uuid('93a9c7b7', include_text=True)

[Passage(name='Genesis 8:22',
references=[Reference(book='Genesis', chapter=8, verse=22)],
text='While the earth remains, seedtime and harvest, cold
and heat, summer and winter, day and night, shall not
cease."'),
...]
```



Preprocess

```
> python -m ecce nave-export
```

```
Writing to ecce/data/exported/nave-by-reference.json
```

```
Writing to ecce/data/exported/nave-by-topic.json
```

```
INFO:root:Loading ESV JSON...
```

```
Writing to ecce/data/exported/nave-subtopic-nodes.tsv
```

```
Writing to ecce/data/exported/nave-passages.json
```

```
Writing to ecce/data/exported/nave-category-nodes.tsv
```

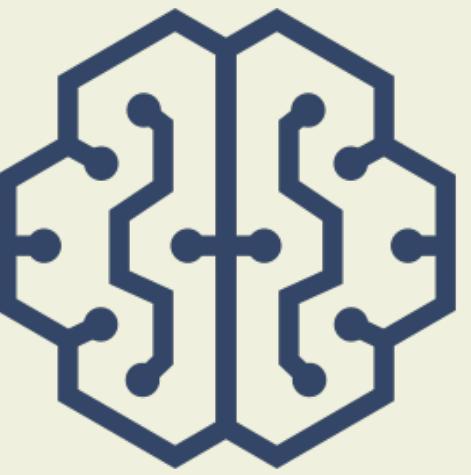
```
Writing to ecce/data/exported/nave-topic-nodes.tsv
```

```
> python -m ecce topic-export
```

```
Writing to ecce/data/exported/verse-with-topics.tsv
```

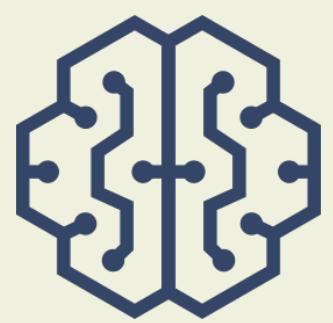
```
100%|██████████| 214121/214121 [00:19<00:00, 10834.65it/s]
```

```
INFO:root:Loading ESV JSON...
```



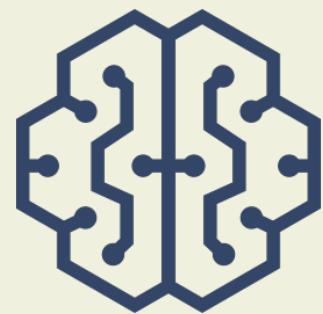
Model





Model





Model

```
from ecce.model.ecce import EcceModel

m = EcceModel('ecce/data/checkpoints/nave-<weights>.hdf5',
               'ecce/data/checkpoints/tsk-cluster-<weights>.hdf5')

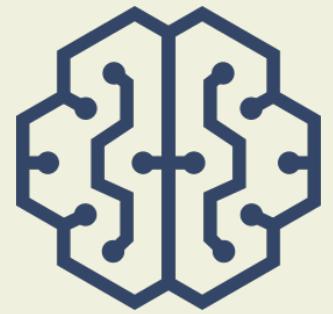
result = m.predict('What is man that you are mindful of him?', top_clusters=2)

print_raw(result.topics)

# [[0.1233958974480629, 'tpc:1494754856', 'QUOTATIONS AND ALLUSIONS'],
# [0.08785395324230194, 'tpc:1487961918', 'JOB'],
# ...]

print_raw(result.passage_topics)

# [[0.12403968987829263, 'tpc:-1776404894', 'PHILOSOPHY'],
# [0.12403968987829263, 'tpc:1071709628', 'ELIHU'],
# ...]
#
# (continued)
```



Model

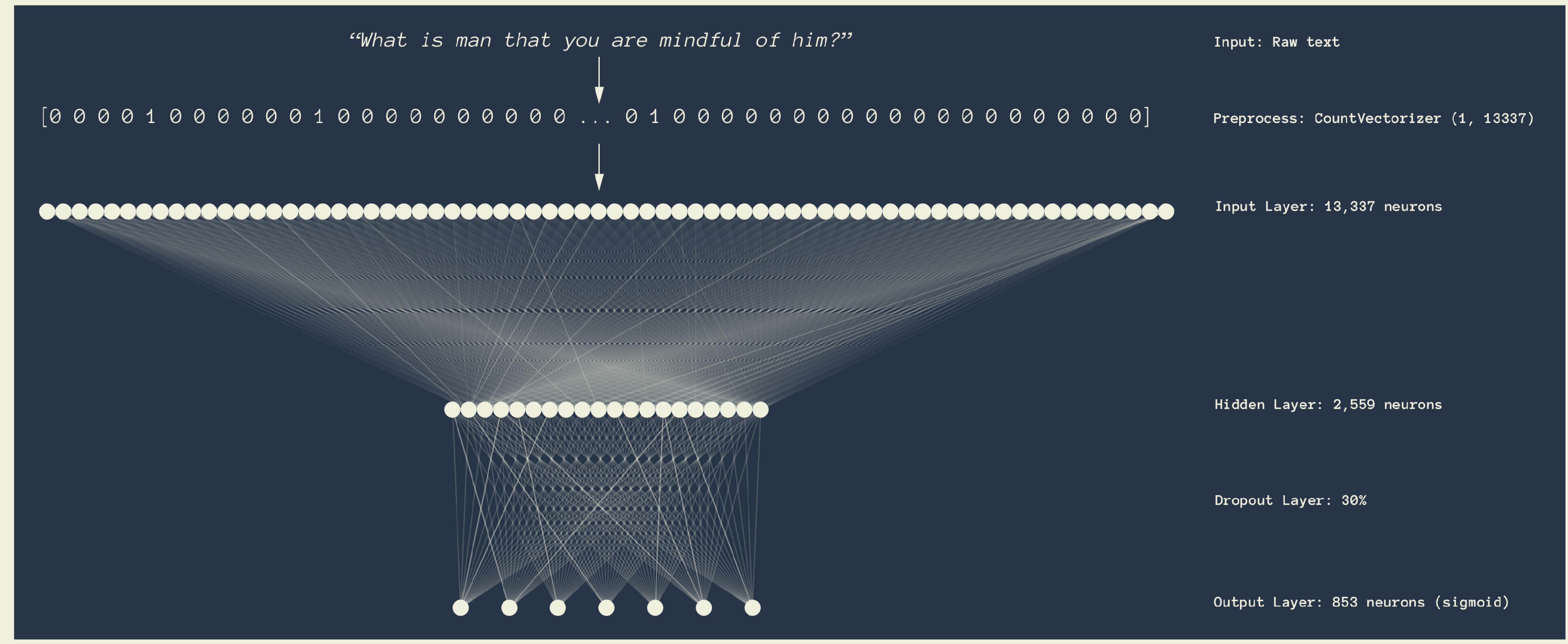
```
print_raw(result.clusters)
```

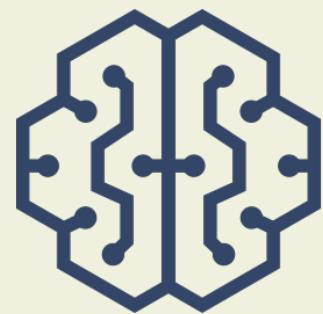
```
# [[0.018426116555929184,
#   '00b37c33',
#   ['Isaiah', 2, 22],
#   'Stop regarding man in whose nostrils is breath, for of what account is he?',
#   [['Job 7:15-21',
#     [...],
#     '15 so that I would choose strangling and death rather than my bones.\n'
#     '16 I loathe my life...']],
#   ['Psalms 8:4',
#     [...],
#     'what is man that you are mindful of him...'],
#   ['Psalms 144:3-4',
#     [['Psalms', 144, 3], ...],
#     '3 O LORD, what is man that you regard him...]]],
# [...,
# [0.01758749410510063,
#   ...]]
```

Topic Model

36,315,622 params, ~435MB, 13.61% categorical accuracy

Model





Model - Nave

```
> python -m ecce train-nave -p 1
```

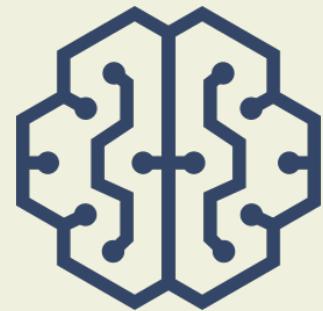
```
INFO:root:Splitting train/val/test data...
```

```
WARNING:root:Skipping 73 verses with no assigned topics.
```

```
INFO:root:Loading ESV JSON...
```

```
INFO:root:Training...
```

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	(None, 13337)	0
dense_1 (Dense)	(None, 2559)	34131942
dropout_1 (Dropout)	(None, 2559)	0
dense_2 (Dense)	(None, 853)	2183680
<hr/>		
Total params: 36,315,622		
Trainable params: 36,315,622		
Non-trainable params: 0		
<hr/>		
Train on 20837 samples, validate on 3678 samples		
<hr/>		



Model

...

```
Epoch 1/20
20837/20837 [=====] - 4s 209us/step - loss: 31.1644 -
categorical_accuracy: 0.0185 - val_loss: 28.7527 - val_categorical_accuracy: 0.0212
Epoch 2/20
20837/20837 [=====] - 3s 132us/step - loss: 25.2262 -
categorical_accuracy: 0.0259 - val_loss: 24.8144 - val_categorical_accuracy: 0.0201
Epoch 3/20
20837/20837 [=====] - 3s 132us/step - loss: 20.3705 -
categorical_accuracy: 0.1137 - val_loss: 23.1124 - val_categorical_accuracy: 0.1278
Epoch 4/20
20837/20837 [=====] - 3s 132us/step - loss: 17.3195 -
categorical_accuracy: 0.1922 - val_loss: 22.7056 - val_categorical_accuracy: 0.1283
Epoch 5/20
20837/20837 [=====] - 3s 131us/step - loss: 15.4237 -
categorical_accuracy: 0.2163 - val_loss: 22.6880 - val_categorical_accuracy: 0.1346
Epoch 6/20
20837/20837 [=====] - 3s 132us/step - loss: 14.1374 -
categorical_accuracy: 0.2321 - val_loss: 22.9306 - val_categorical_accuracy: 0.1213
Evaluating...
6129/6129 [=====] - 0s 73us/step
Accuracy 13.17%
```

Cluster Model

191,259,581 params, ~2.2GB, 1.32% categorical accuracy

Model 

"What is man that you are mindful of him?"

[0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 ... 0 1 0]

[0.01630 0.00764 0.01222 0.00439 0.00312 0.00030 ... 0.01010 0.01403 0.41076 0.02280 0.00990 0.00682
0.07139 0.00178 0.00111 0.01301 0.01518 0.00508 ... 0.06206 0.00645 0.08204 0.00573 0.01409 0.00269
...
0.02322 0.00012 0.00979 0.00710 0.00355 0.00587 ... 0.02980 0.01590 0.01335 0.01518 0.01507 0.00905
0.00969 0.00930 0.00116 0.00061 0.01989 0.06437 ... 0.01476 0.01247 0.00883 0.01896 0.00638 0.01196]

Input: Raw text

Preprocess: CountVectorizer (1, 13337)

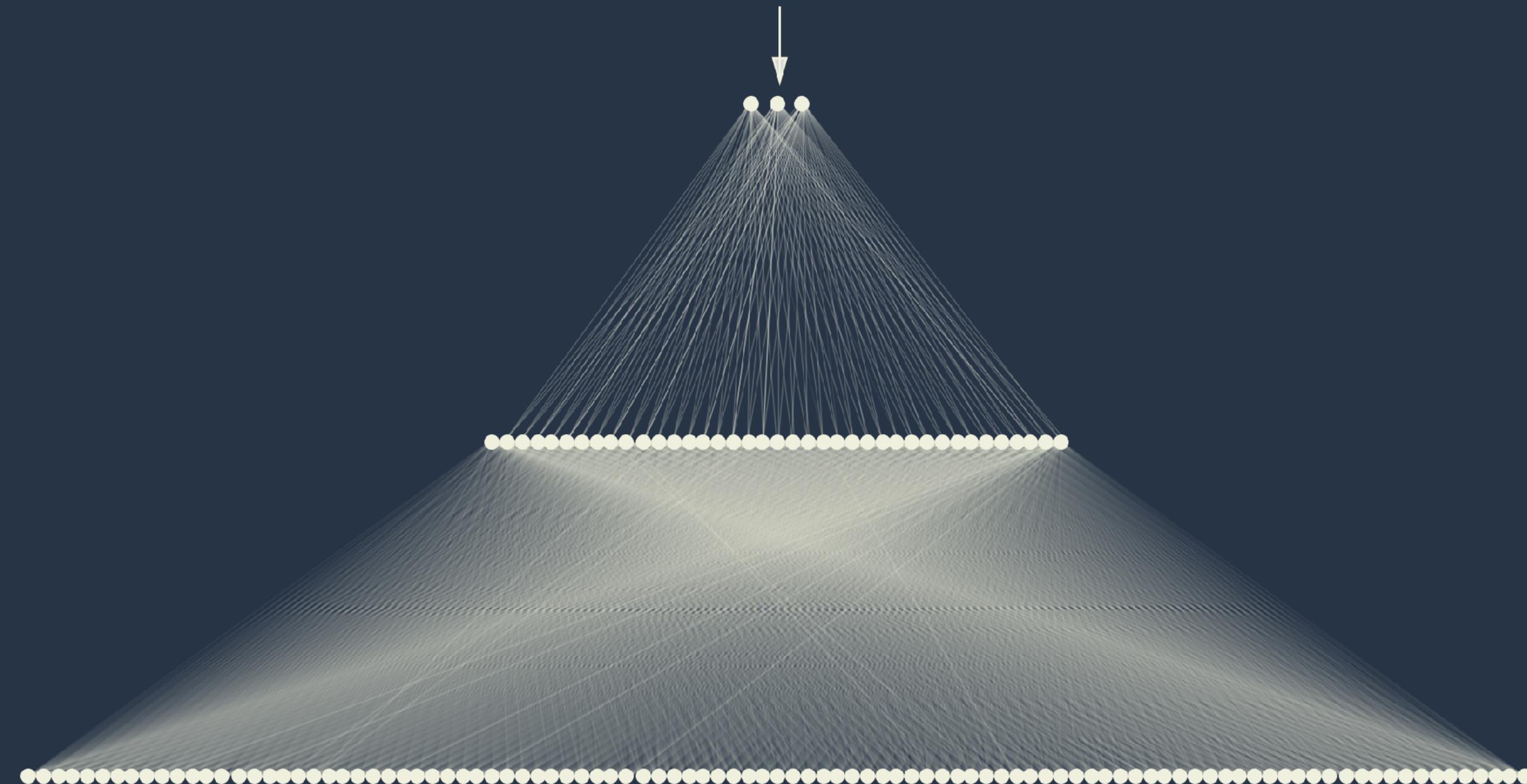
Preprocess:
Truncated Singular Value Decomposition
(~ Latent Semantic Analysis)
Shape: (1, 150)

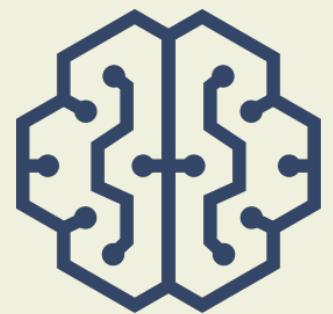
Input Layer: 150 neurons

Hidden Layer: 3,000 neurons

Dropout Layer: 20%

Output Layer: 63,581 neurons (softmax)





Model - Cluster

```
> python -m ecce train-tsk -p 1
```

```
INFO:root:Splitting train/val/test data...
```

```
INFO:root:Training...
```

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	(None, 150)	0
dense_1 (Dense)	(None, 3000)	453000
dropout_1 (Dropout)	(None, 3000)	0
dense_2 (Dense)	(None, 63581)	190806581

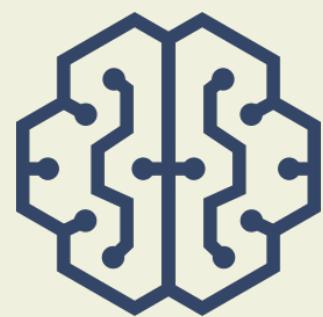
```
Total params: 191,259,581
```

```
Trainable params: 191,259,581
```

```
Non-trainable params: 0
```

```
Train on 21106 samples, validate on 3725 samples
```

```
...
```



Model - Cluster

```
...  
Epoch 1/20  
21106/21106 [=====] - 49s 2ms/step - loss: 224.7334 -  
categorical_accuracy: 0.0028 - val_loss: 218.4070 - val_categorical_accuracy:  
0.0059  
Epoch 2/20  
21106/21106 [=====] - 44s 2ms/step - loss: 176.1291 -  
categorical_accuracy: 0.0197 - val_loss: 214.3273 - val_categorical_accuracy:  
0.0142  
Epoch 3/20  
21106/21106 [=====] - 44s 2ms/step - loss: 128.7382 -  
categorical_accuracy: 0.0536 - val_loss: 220.1996 - val_categorical_accuracy:  
0.0129  
Epoch 4/20  
21106/21106 [=====] - 44s 2ms/step - loss: 108.4135 -  
categorical_accuracy: 0.0671 - val_loss: 226.4115 - val_categorical_accuracy:  
0.0142  
Evaluating...  
6208/6208 [=====] - 3s 561us/step  
Accuracy 1.32%
```



Evaluate





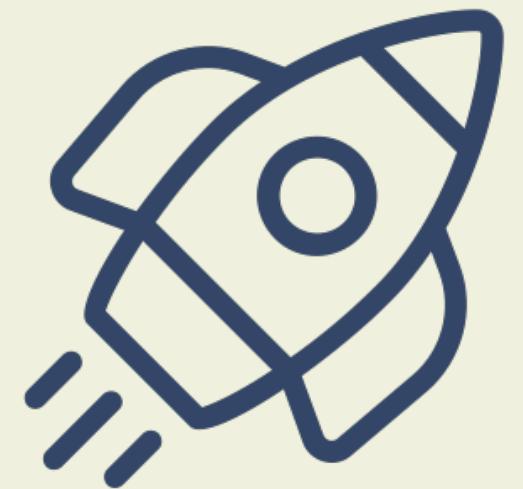
Evaluate - Nave

Name	Categorical Accuracy	Notes
Istm-base	2.95%	sequence of words, no word embeddings, ~4200 possible topics
Istm-b4cab4	5.72%	tuned and tweaked, reduce to ~850 topics, word embeddings from glove. 42B.300d (includes 92.55% of ESV words)
svd-bow-cb8915	6.91%	switch to truncated SVD with bag-of-words
svd-bow-52a075	6.62%	additional experiments, exclude top two topics
svd-bow-88bf90	8.21%	make SVD 200 components (102% of last model size)
svd-bow-ced288	7.06%	make SVD 150 components (200 was too big for initial production machine)
nave-4576e8	13.61%	properly filter topics and remove SVD due to smaller model size, use vocabulary count vectorizer as direct input



Evaluate - TSK

Name	Categorical Accuracy	Notes
tsk-cluster-87b509	0.25%	initial fully-connected model
tsk-cluster-f13345	0.33%	add dropout layers and tweak architecture
tsk-cluster-1d7203	1.05%	fix verses to have multiple uuids
tsk-cluster-26869f	1.14%	add hidden layer and overfit with 10 patience epochs
tsk-cluster-4e1698	1.16%	make SVD 200 components (doubled model size)
tsk-cluster-47f717	1.24%	make SVD 150 components (200 was too big for production)
tsk-cluster-8a1db9	1.32%	change epoch patience to 2 instead of 3



Deploy

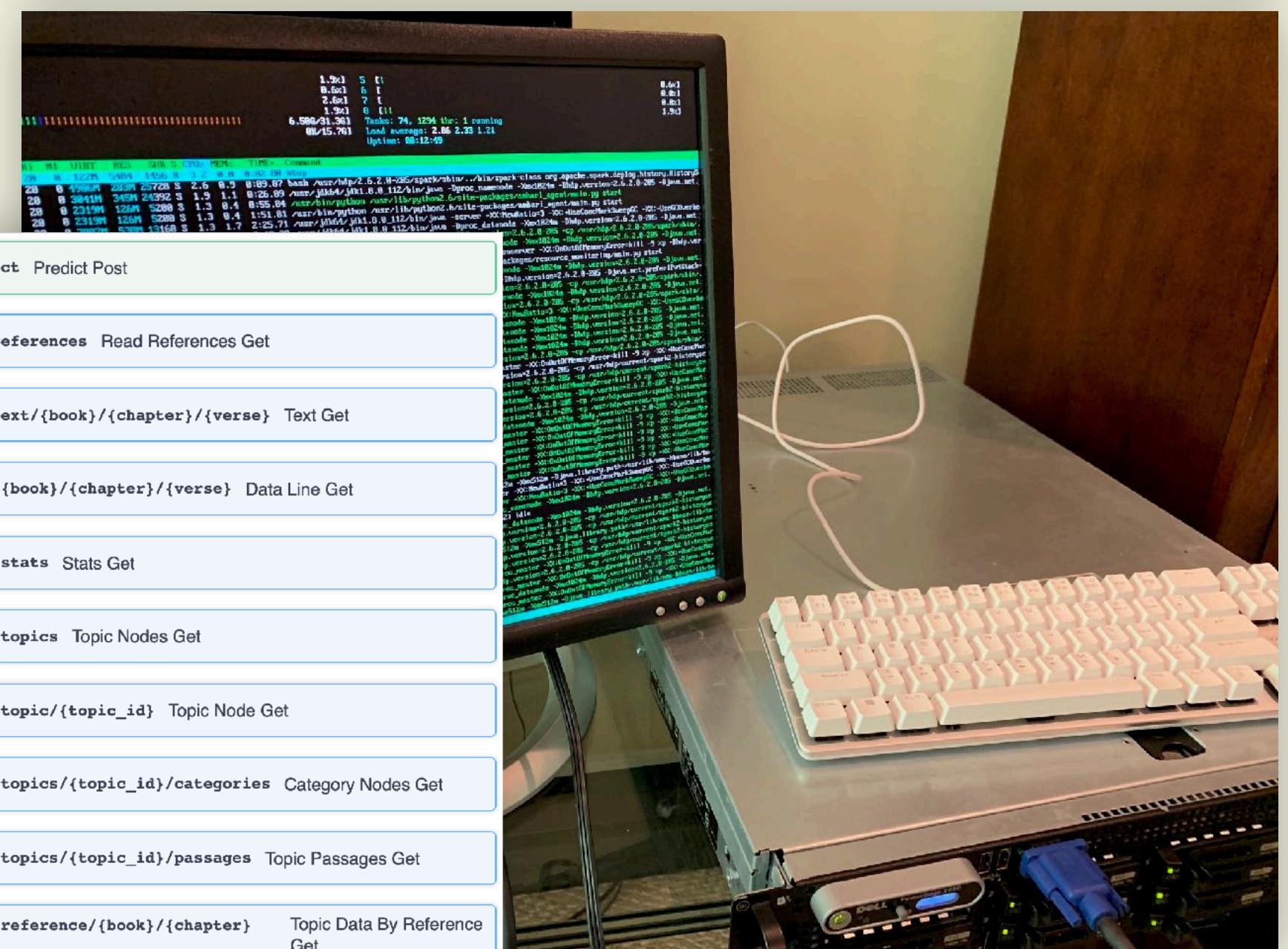
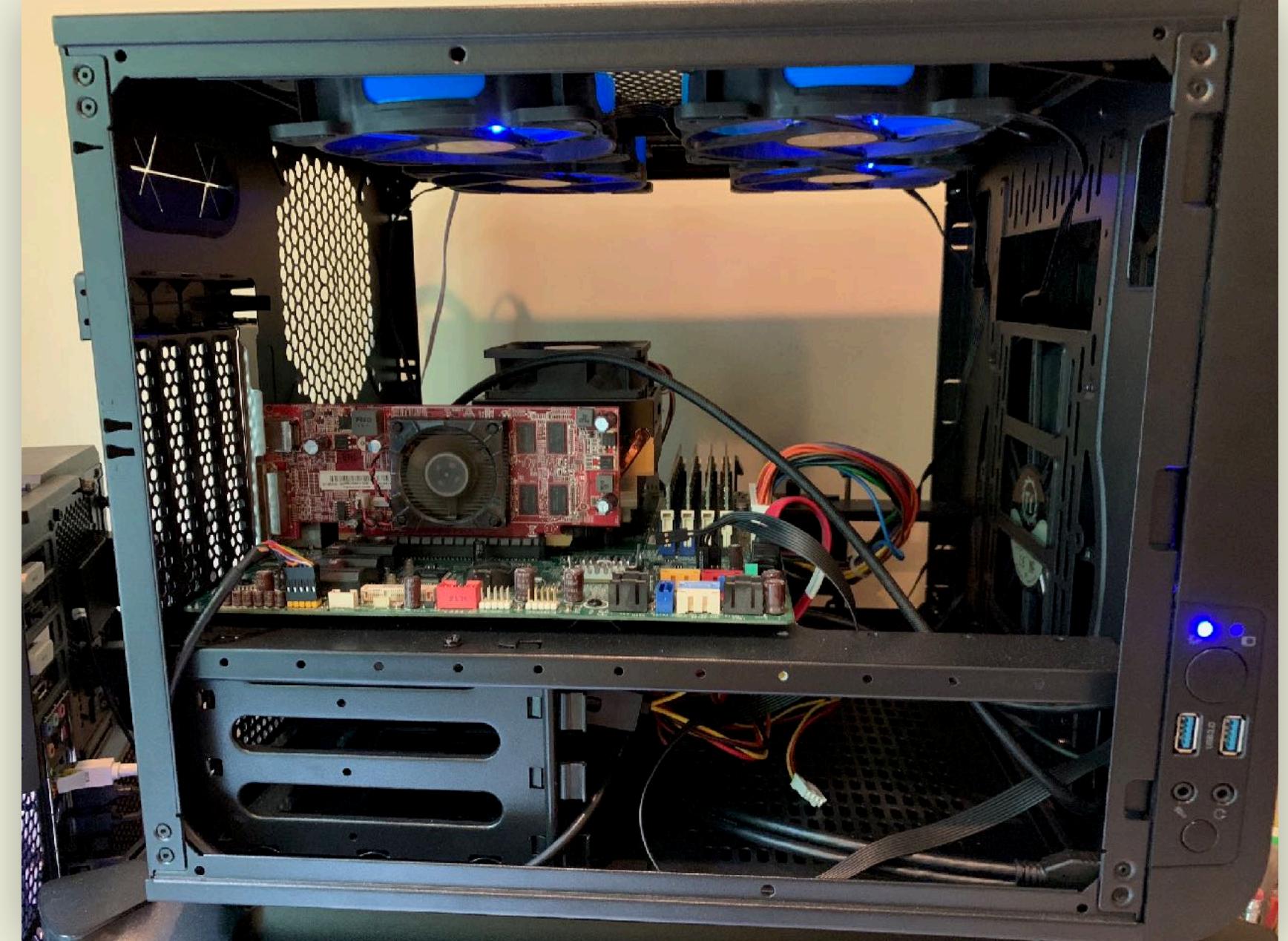




Deploy

- Fastapi (Python) with React.js
- Server / client hosted separately
- Self-hosted (changed from DigitalOcean)
- Reverse proxy with Nginx

POST	/api/predict Predict Post
GET	/api/esv/references Read References Get
GET	/api/esv/text/{book}/{chapter}/{verse} Text Get
GET	/api/data/{book}/{chapter}/{verse} Data Line Get
GET	/api/data/stats Stats Get
GET	/api/nave/topics Topic Nodes Get
GET	/api/nave/topic/{topic_id} Topic Node Get
GET	/api/nave/topics/{topic_id}/categories Category Nodes Get
GET	/api/nave/topics/{topic_id}/passages Topic Passages Get
GET	/api/nave/reference/{book}/{chapter}/{verse} Topic Data By Reference Get
GET	/api/passages/default Default Passages Get





Deploy - Metrics

The image shows two overlapping dashboards. The background dashboard is titled "Ecce - 2019-04-29 - Web Analy" and displays a "RCDAI" logo. It features a flow diagram with "Direct Entries" and "From Social Networks" leading to "33 pageviews". Below this is a table of incoming traffic sources, with "11 from social networks" highlighted in red. The foreground dashboard is titled "Chronograf" and shows "Ecce Prediction". It includes a gauge chart for "Prediction Response Time" (3.30s) and a line graph for "ecce_predict.mean_duration" over time (11:00 to 11:25). A table titled "Prediction Requests" lists several AI queries and their timestamps.

Ecce - 2019-04-29 - Web Analy

RCDAI

33 pageviews

Incoming traffic

- 0 from internal pages
- 0 from internal searches
- 0 from search engines
- 11 from social networks**
- 0 from websites
- 0 from campaigns
- 6 direct entries

Outgoing traffic

- 0 to internal pages
- 0 internal searches
- 0 downloads
- 2 outputs
- 17 page reloads

16 page reloads

Ecce Prediction

Prediction Response Time

ecce_predict.mean_duration

11:00 11:05 11:10 11:15 11:20 11:25

4
3.5
3
2.5
2

Prediction Requests

time	ecce_predict.text
04/30/2019 11:12:48	Kingdom of heaven
04/30/2019 11:14:20	When did Israel leave Egypt?
04/30/2019 11:16:04	Why are we called Christians?
04/30/2019 11:16:48	Why is there evil in the world?
04/30/2019 11:17:27	Birth of christ
04/30/2019 11:18:02	Why do we have marriage?\n

Ecce - Bible Explorer

ecce.rcd.ai

VERSES TOPICS ABOUT

Bible Text AI

Enter part of a verse or a phrase we'll try to find related Biblical topics and passages

What is man that you are mindful of him?

Find

Topics

QUOTATIONS AND ALLUSIONS JOB

PSALMS MAN PRAISE PROPHECY

CONDESCENSION OF GOD SIN (1)

RELIGION

Linked Passage Themes

VANITY PHILOSOPHY ELIHU

INFIDELITY MOABITES PISGAH TRUTH

WORLDLINESS HYPOCRISY SORCERY

Passages

Isaiah 2:22
Stop regarding man in whose nostrils is breath, for of what account is he? [READ MORE](#)

Job 9:32
For he is not a man, as I am, that I might answer him, that we should come to trial together. [READ MORE](#)

Mark 7:15
There is nothing outside a person that by going into him can defile him, but the things that come out of a person are what defile him. [READ MORE](#)

Appendix

- Python Libraries
fastapi, funcy, keras, lenses, numpy, pandas, PyMonad,
scikit-learn, tensorflow, toolz, tqdm, uvicorn, gunicorn
- Technologies
PyEnv, Virtualenv, Nginx, create-react-app, GitHub
- Hardware
Dev: i7700K, 64 GB RAM, Samsung 850 EVO SSD, 2 NVIDIA 1080 Ti's, Ubuntu 18.04
Prod
Client: HP, AMD Quad-Core Phenom II X4 955 3.2GHz , 8GB RAM, Ubuntu
API: PowerEdge 2950, 2 Quad-Core Xeon's at 2.5GHz, 32GB ECC RAM
RAID w/ 10k ATA drives, Centos