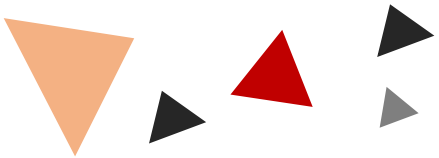

Deep Classification, Embedding & Text Generation

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CONTENTS

Data

- ✓ **Amazon review data (2018) with 233.1 million reviews**
- ✓ **In this homework, we conducted on a small scope:**
- **Sub-Category: Video Games (400,000 inputs)**
- **Select First 5,000 queries in the video games**
- **Goal: Understand reviewers' behavior and extract high-level information from it**

	overall	verified	reviewTime	reviewerID	asin	reviewerName	reviewText	summary	unixReviewTime
0	5	True	10 17, 2015	A1HP7NVNPFMA4N	700026657	Ambrosia075	This game is a bit hard to get the hang of, bu...	but when you do it's great.	1445040000
1	4	False	07 27, 2015	A1JGAP0185YJI6	700026657	travis	I played it a while but it was alright. The st...	But in spite of that it was fun, I liked it	1437955200
2	3	True	02 23, 2015	A1YJWEXHQBWK2B	700026657	Vincent G. Mezera	ok game.	Three Stars	1424649600
3	2	True	02 20, 2015	A2204E1TH211HT	700026657	Grandma KR	found the game a bit too complicated, not what...	Two Stars	1424390400
4	5	True	12 25, 2014	A2RF5B5H74JLPE	700026657	jon	great game, I love it and have played it since...	love this game	1419465600

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	label	reviewerID	reviewText
0	1	A1HP7NVNPFMA4N	This game is a bit hard to get the hang of, bu...
1	0	A1JGAP0185YJI6	I played it a while but it was alright. The st...
2	0	A1YJWEXHQBWK2B	ok game.
3	0	A2204E1TH211HT	found the game a bit too complicated, not what...
4	1	A2RF5B5H74JLPE	great game, I love it and have played it since...

- **Manually re-labelled the data**

to binary variables

- **Distribution:**

5-star(labelled as 1): 3388

4-star(labelled as 0): 1612

Deep Neural Nets (Keras)

```
Epoch 1/10
4500/4500 [==============================] - 31s 7ms/step - loss: 0.6249 - accuracy: 0.6758
Epoch 2/10
4500/4500 [==============================] - 29s 6ms/step - loss: 0.6035 - accuracy: 0.6987
Epoch 3/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.5381 - accuracy: 0.7558
Epoch 4/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.6088 - accuracy: 0.6798
Epoch 5/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.5047 - accuracy: 0.7704
Epoch 6/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.5450 - accuracy: 0.7584
Epoch 7/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.4611 - accuracy: 0.8029
Epoch 8/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.4631 - accuracy: 0.8096
Epoch 9/10
4500/4500 [==============================] - 28s 6ms/step - loss: 0.4016 - accuracy: 0.8324
Epoch 10/10
4500/4500 [==============================] - 27s 6ms/step - loss: 0.3628 - accuracy: 0.8529
```

- **Keras (LSTM):**

high-level package that we don't bother every detail or hyperparameters associated with neural Network

- **Results:**

Accuracy: 67 – 85%

Run-time: ~290s

Fairly fine accuracy but with high variance (?)

Deep Neural Nets (Keras)

```
Epoch 1/10
4500/4500 [==============================] - 93s 21ms/step - loss: 0.6272 - accuracy: 0.6780
Epoch 2/10
4500/4500 [==============================] - 88s 20ms/step - loss: 0.5946 - accuracy: 0.7084
Epoch 3/10
4500/4500 [==============================] - 89s 20ms/step - loss: 0.5224 - accuracy: 0.7711
Epoch 4/10
4500/4500 [==============================] - 90s 20ms/step - loss: 0.5708 - accuracy: 0.7449
Epoch 5/10
4500/4500 [==============================] - 90s 20ms/step - loss: 0.4352 - accuracy: 0.8193
Epoch 6/10
4500/4500 [==============================] - 90s 20ms/step - loss: 0.3547 - accuracy: 0.8511
Epoch 7/10
4500/4500 [==============================] - 89s 20ms/step - loss: 0.3106 - accuracy: 0.8722
Epoch 8/10
4500/4500 [==============================] - 88s 20ms/step - loss: 0.2598 - accuracy: 0.9027
Epoch 9/10
4500/4500 [==============================] - 89s 20ms/step - loss: 0.2267 - accuracy: 0.9204
Epoch 10/10
4500/4500 [==============================] - 89s 20ms/step - loss: 0.2098 - accuracy: 0.9260
```

Added one more layer

- **Results:**

Accuracy: 67 – 92% (better)

Run-time: ~900s (3 times than before)

Better than one layer with the largest accuracy of 92.6% (super excellent!)

But much more time-consuming (costly)

BERT (bidirectional transformer embedding)

```
======== Epoch 1 / 4 ========
Training...
  Batch    40  of    141.    Elapsed: 0:00:16.
  Batch    80  of    141.    Elapsed: 0:00:31.
  Batch   120  of    141.    Elapsed: 0:00:46.

  Average training loss: 0.53
  Training epcoh took: 0:00:54

Running Validation...
  Accuracy: 0.78
  Validation took: 0:00:02

======== Epoch 2 / 4 ========
Training...
  Batch    40  of    141.    Elapsed: 0:00:15.
  Batch    80  of    141.    Elapsed: 0:00:30.
  Batch   120  of    141.    Elapsed: 0:00:45.

  Average training loss: 0.40
  Training epcoh took: 0:00:53

Running Validation...
  Accuracy: 0.81
  Validation took: 0:00:02
```

```
======== Epoch 3 / 4 ========
Training...
  Batch    40  of    141.    Elapsed: 0:00:15.
  Batch    80  of    141.    Elapsed: 0:00:30.
  Batch   120  of    141.    Elapsed: 0:00:45.

  Average training loss: 0.30
  Training epcoh took: 0:00:53

Running Validation...
  Accuracy: 0.80
  Validation took: 0:00:02

======== Epoch 4 / 4 ========
Training...
  Batch    40  of    141.    Elapsed: 0:00:15.
  Batch    80  of    141.    Elapsed: 0:00:30.
  Batch   120  of    141.    Elapsed: 0:00:45.

  Average training loss: 0.22
  Training epcoh took: 0:00:53

Running Validation...
  Accuracy: 0.80
  Validation took: 0:00:02
```

BERT Model

- **Results:**

Training Loss: 0.22 – 0.52

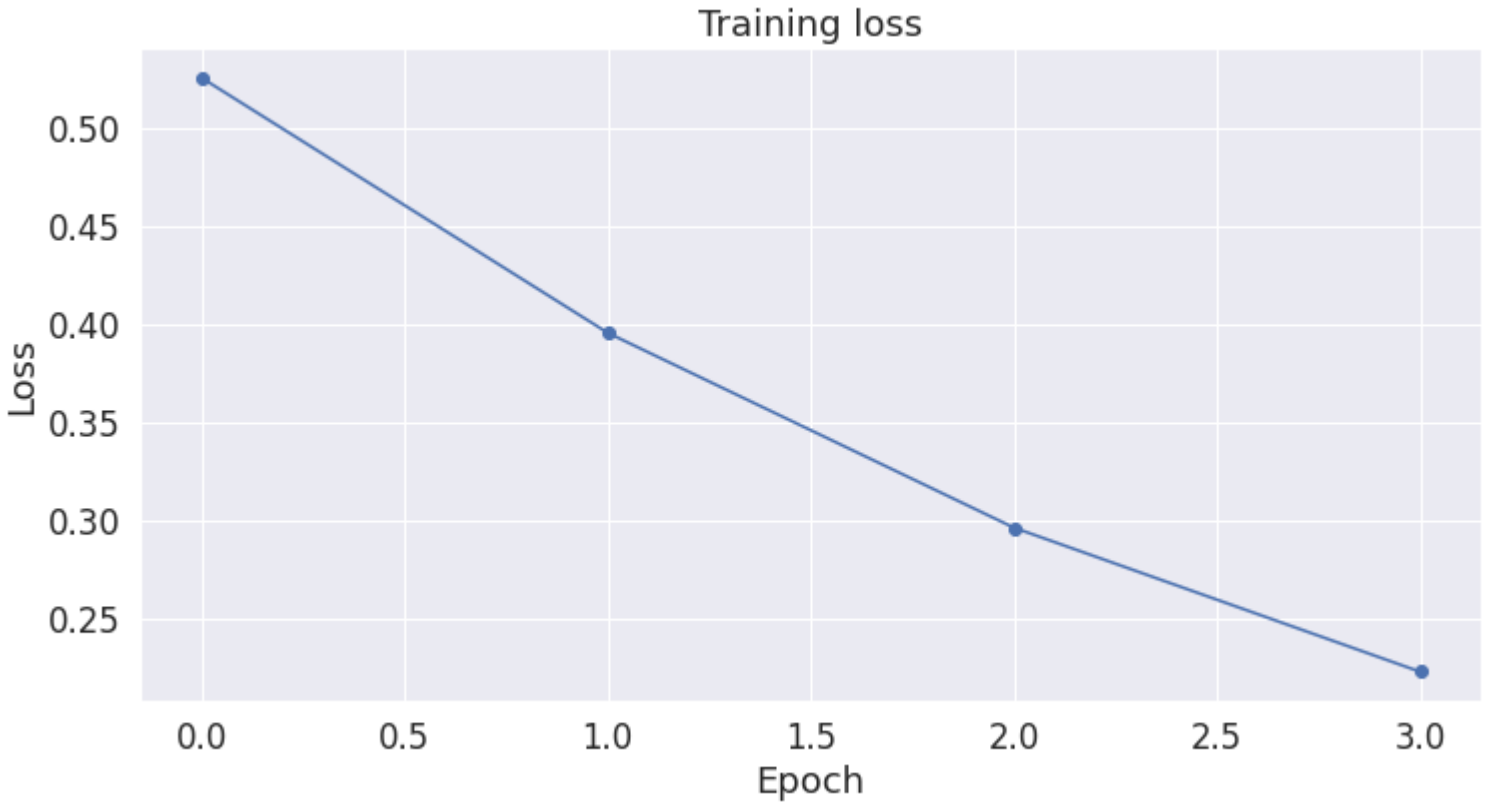
Accuracy: 78 – 81%

Run-time: ~210s on Colab

(~12h on local machine)

Fairly accurate with low variance but with strong reliance on GPU

BERT (bidirectional transformer embedding)



Some Findings:

- **When Epoch = 3.0, training loss can become half of the Epoch = 0.0**
- **As Epoch numbers increase, the training loss decreases.**
- **Generally speaking, it performs better than LSTM.**

Model Evaluation

- ✓ Number of test sentences: 5,000
- ✓ Positive samples (1): 3388 of 5000 (67.76%)
- ✓ MCC (Matthews Correlation Coefficient): 0.845

Excellent Prediction!

Some Findings:

- **Keras and BERT performs much better than the traditional models but also time-consuming (rely on GPU.)**

Model	Error rate	Model	Error rate
Keras(two-layer)	0.18(avg.)	Decision Tree	0.39
BERT	0.19(avg.)	Random Forest	0.41
Logistic Regression	0.36	KNN	0.24
Naïve Bayes	0.32	Neural Network	0.42

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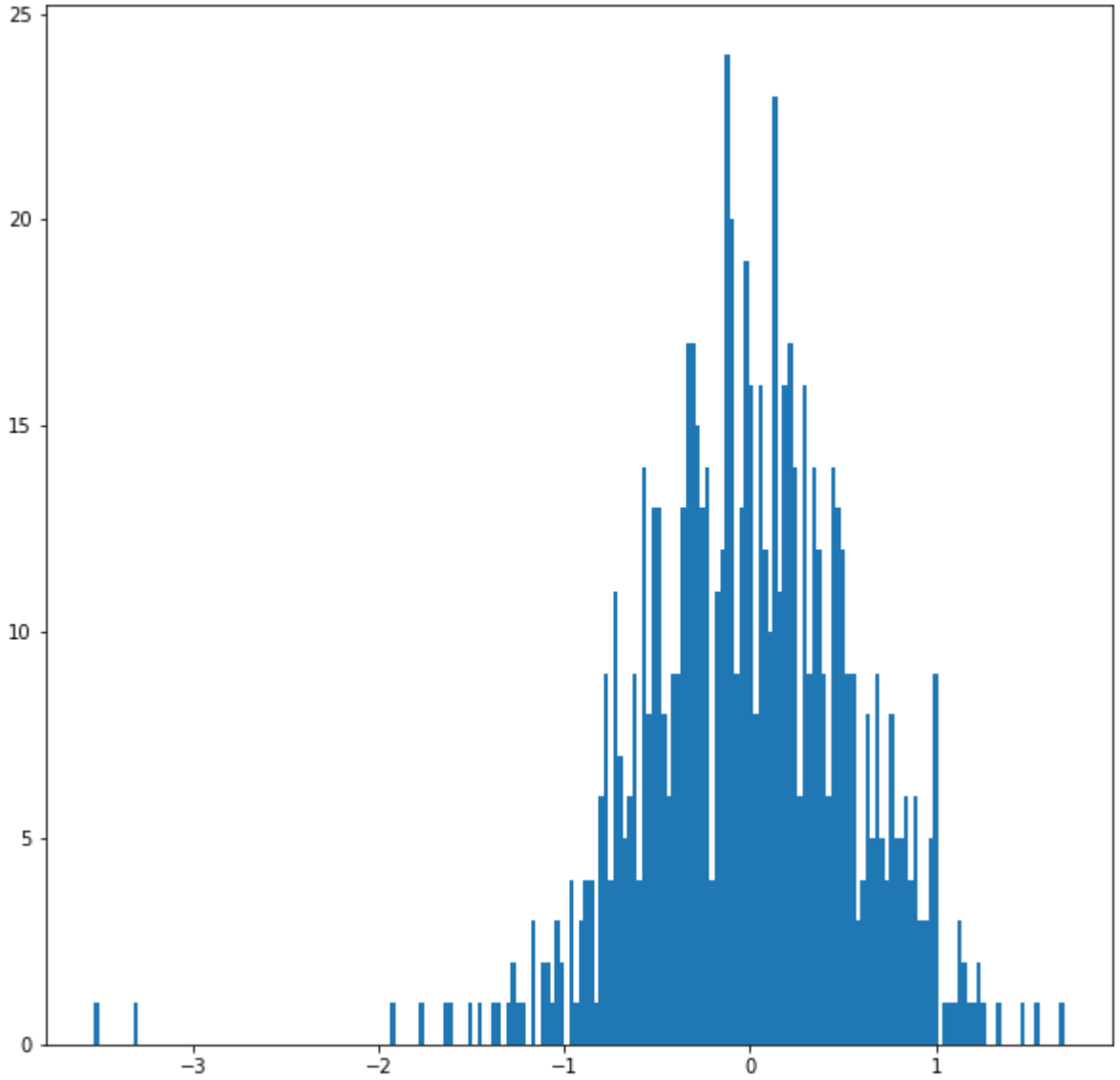
Word Embeddings

The distribution of range of values

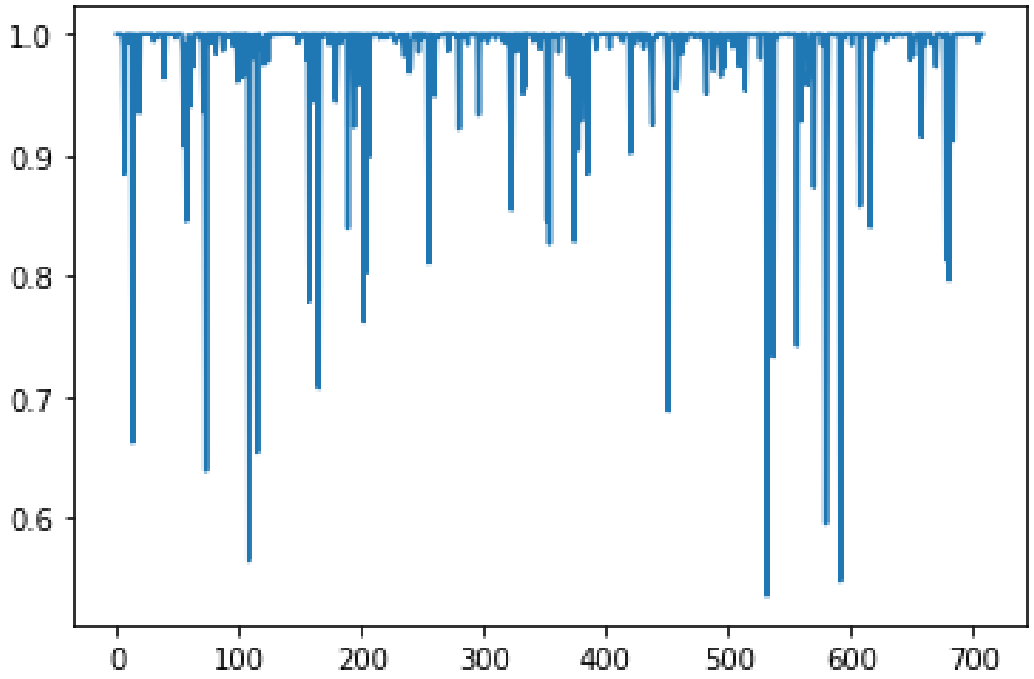
for word embeddings for BERT:

- **Majority around [-1, 1] (a little bit more in the negative side)**
- **With several outliers near -4**

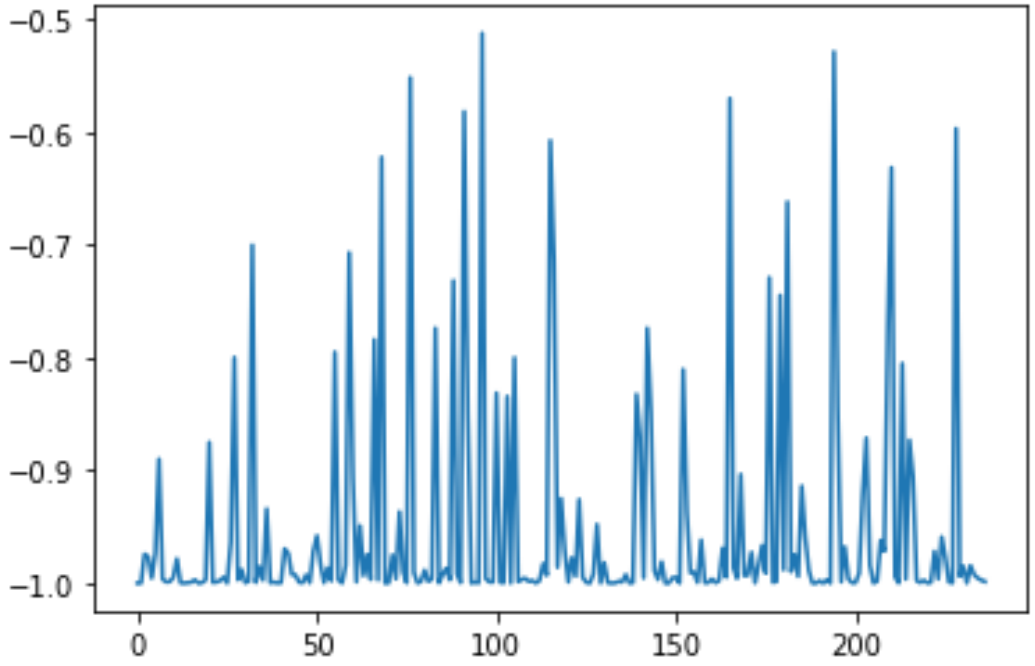


Transformers Pipeline (sentiments)

Positive



Negative



Some Findings:

- **More positive than negative (around 3:1)**
- **Strong positive and weak negative (bigger variance)**

Text Generation (all data)

- ✓ **All dataset: 5000 inputs**
- ✓ **Train/Test split: 0.2 (Train: 4000, Test: 1000)**
- ✓ **Begin words for text generation: This game**

```
=== GENERATED SEQUENCE 1 ===
This game was remarkably innovative and fun.  It has a complete line of games to choose from, such as
```

Findings:

- **High-level pattern: Tend to be very positive (innovative and fun)**
- **It matches with the fairly positive sentimental score shown in the prior presentation**

Text Generation (all data)

✓ **Begin words for text generation: I like this video game because**

```
I like this video game because it's fun and it's fun to play. I also like the fact that you can play as a character and hav
e a lot of fun. I also like the fact that you can play as a character and have a
```

✓ **Begin words for text generation: I don’t like this video game because**

```
I don't like this video game because it's so boring.  I don't like the graphics, but I like the gameplay.  I like the stor
y, but I don't like the characters.  I like the music, but I don
```

- **Interesting to see that it can generate make-sense positive and negative sentence**

Text Generation (five-star data)

- ✓ **Five-star dataset: 500 inputs (all five-star)**
- ✓ **Train/Test split: 0.2 (Train: 400, Test: 100)**
- ✓ **Begin words for text generation: This game**

```
=== GENERATED SEQUENCE 1 ===
This game is fun enough for both new and old players alike, but it's not as intense as the original.
```

Findings:

- **High-level pattern: Positive**
- **Interestingly, it generates a “but” here in all five-star comments.**

Text Generation (not-five-star data)

- ✓ **Five-star dataset: 500 inputs (all not five-star)**
- ✓ **Train/Test split: 0.2 (Train: 400, Test: 100)**
- ✓ **Begin words for text generation: This game**

```
=== GENERATED SEQUENCE 1===
This game is boring. I don't like the graph, but I like the game settings.
```

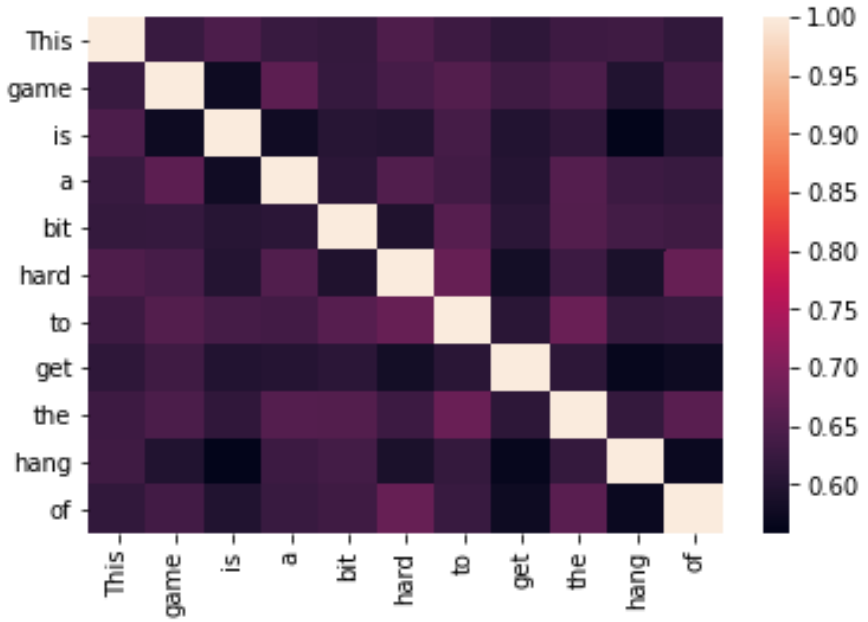
Findings:

- **High-level pattern: Negative (The text-generation really makes sense!)**
- **Interestingly, it also generates a “but” here.**

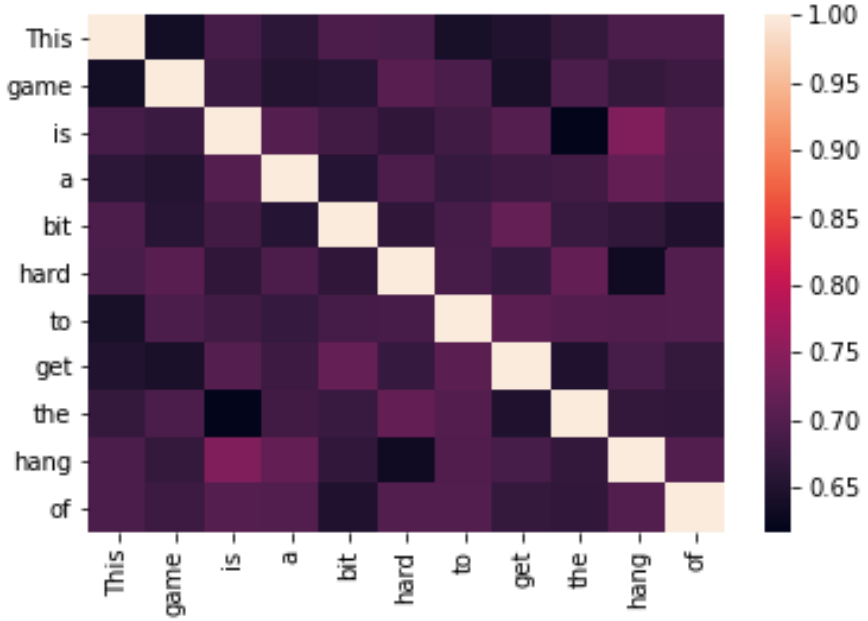
Heatmap

✓ **Text: "This game is a bit hard to get the hang of."**

All reviews



All five-star reviews



Findings:

- **Hard to distinguish between these two datasets for this text**
- **Maybe because words in this text in so common to use.**

Conclusion

✓ **Deep Classification:**

- **Keras and Bert performs better than the traditional ML models (half of the error rates)**
- **But they are more costly (time-consuming and relies on GPU)**

✓ **Word Embeddings:**

- **Most words embeddings around [-1, 1]**
- **More positive sentiments than negative and positive tends to be much stronger**

✓ **Text Generation:**

- **Can excellently generate sentences make sense (fit to the grammar, topic and sentiments)**
- **Interestingly, it “loves” to use “but”**
- **Hard to distinguish sentences heatmap between different models and datasets**

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