# Fake News Detection

**CSE 290T course project**

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- Introduction
- Data & Process
- Baseline Models
- DNN
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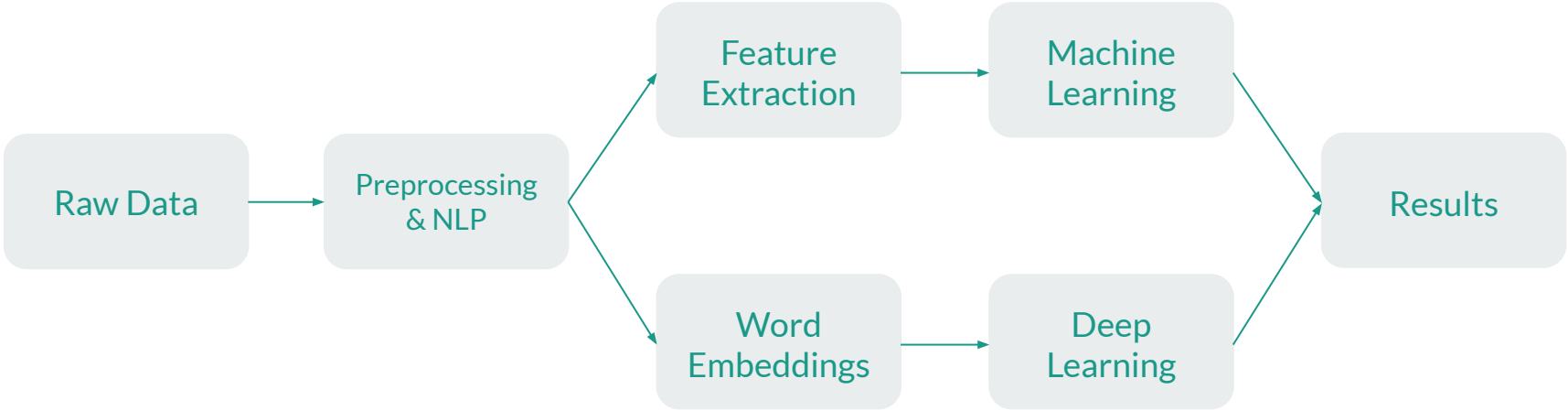
- Conclusion

Source: https://www.legalzoom.com/articles/fake-news-what-laws-are-designed-to-protect

# Framework


Raw Data
Preprocessing & NLP
Feature Extraction
Machine Learning
Word Embeddings
Deep Learning
Results

# Comparing Results

Best accuracy of traditional algorithms:

95.46% ----- **logistics regression**

Best accuracy of deep learning algorithms:

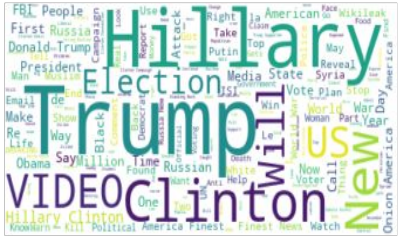
99.91% ----- RNN with Attention

# Data

- 20386 transactions
- Attributes & distribution:
  - 1: unreliable
  - 0: reliable



True news




Fake news

| id | title | author | text | label |
|---|---|---|---|---|
| 0 | House Dem Aide: We Didn't Even See Comey's Let... | Darrell Lucus | House Dem Aide: We Didn't Even See Comey's Let... | 1 |
| 1 | FLYNN: Hillary Clinton, Big Woman on Campus - ... | Daniel J. Flynn | Ever get the feeling your life circles the rou... | 0 |
| 2 | Why the Truth Might Get You Fired | Consortiumnews.com | Why the Truth Might Get You Fired October 29, ... | 1 |

# Data

- Handle missing value and noise:
  - Missing value
    - (text: #39): drop
    - Author, tittle: fill default value
  - Outliers: length shorter than < 10: drop

- Train and validation split (80% : 20%):
  - Stratified
  - Shuffle

# Baseline Models

| | text | label |
|---|---|---|
| 0 | House Dem Aide: We Didn't Even See Comey's Let... | 1 |
| 1 | Ever get the feeling your life circles the rou... | 0 |
| 2 | Why the Truth Might Get You Fired October 29, ... | 1 |
| 3 | Videos 15 Civilians Killed In Single US Airstr... | 1 |
| 4 | Print \nAn Iranian woman has been sentenced to... | 1 |
| ... | ... | ... |
| 20795 | Rapper T. I. unloaded on black celebrities who... | 0 |
| 20796 | When the Green Bay Packers lost to the Washing... | 0 |
| 20797 | The Macy's of today grew from the union of sev... | 0 |
| 20798 | NATO, Russia To Hold Parallel Exercises In Bal... | 1 |
| 20799 | David Swanson is an author, activist, journa... | 1 |

20800 rows × 2 columns

NLP:

Tokenization

Stop Words Removal

Stemming

Lemmatization

To Lower

# Baseline Models

| | text | label |
|---|---|---|
| 0 | house dem aide we even see letter until jason ... | 1 |
| 1 | ever get feeling life circle roundabout rather... | 0 |
| 2 | why truth might get you fired october the tens... | 1 |
| 3 | videos civilians killed in single us airstrike... | 1 |
| 4 | print an iranian woman sentenced six year pris... | 1 |
| ... | ... | ... |
| 20795 | rapper unloaded black celebrity met donald tru... | 0 |
| 20796 | when green bay packers lost washington redskin... | 0 |
| 20797 | the today grew union several great name americ... | 0 |
| 20798 | nato russia to hold parallel exercises in balk... | 1 |
| 20799 | david swanson author activist journalist radio... | 1 |

20800 rows × 2 columns

NLP:

Tokenization

Stop Words Removal

Stemming

Lemmatization

To Lower

# Baseline Models

| | text | label |
|---|---|---|
| 0 | house dem aide we even see letter until jason ... | 1 |
| 1 | ever get feeling life circle roundabout rather... | 0 |
| 2 | why truth might get you fired october the tens... | 1 |
| 3 | videos civilians killed in single us airstrike... | 1 |
| 4 | print an iranian woman sentenced six year pris... | 1 |
| ... | ... | ... |
| 20795 | rapper unloaded black celebrity met donald tru... | 0 |
| 20796 | when green bay packers lost washington redskin... | 0 |
| 20797 | the today grew union several great name americ... | 0 |
| 20798 | nato russia to hold parallel exercises in balk... | 1 |
| 20799 | david swanson author activist journalist radio... | 1 |

20800 rows × 2 columns

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

| Index | ‘House’ |
|---|---|
| 0 | 1 |
| 1 | 0 |
| ... | ... |
| 20799 | 0 |

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

| | text | label |
|---|---|---|
| 0 | house dem aide we even see letter until jason ... | 1 |
| 1 | ever get feeling life circle roundabout rather... | 0 |
| 2 | why truth might get you fired october the tens... | 1 |
| 3 | videos civilians killed in single us airstrike... | 1 |
| 4 | print an iranian woman sentenced six year pris... | 1 |
| ... | ... | ... |
| 20795 | rapper unloaded black celebrity met donald tru... | 0 |
| 20796 | when green bay packers lost washington redskin... | 0 |
| 20797 | the today grew union several great name americ... | 0 |
| 20798 | nato russia to hold parallel exercises in balk... | 1 |
| 20799 | david swanson author activist journalist radio... | 1 |

20800 rows × 2 columns

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

| Index | ‘House’ | ‘dem’ |
|---|---|---|
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| ... | ... | ... |
| 20799 | 0 | 0 |

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

| | aaron | abandon | abandoned | abandoning | abbas | abbott | abc | abdel | abdullah | abe | ... | эти | это | этого | этой | этом | этот | является | على | في | من |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 20795 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20796 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20797 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20798 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20799 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

20800 rows × 10000 columns

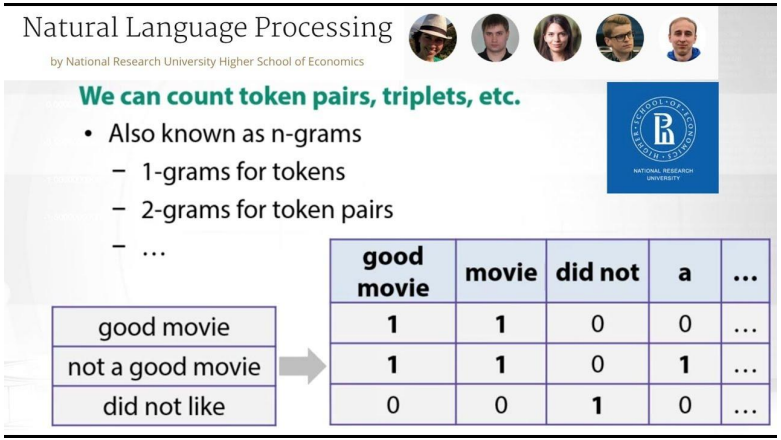
Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models




[ Reference by YouTube ]

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

$$w_{i,j} = tf_{i,j} \times \log\left(\frac{N}{df_i}\right)$$

$tf_{i,j}$ = number of occurrences of $i$ in $j$
$df_i$ = number of documents containing $i$
$N$ = total number of documents

[ Reference by Wiki ]

Measurement: frequency

→ relevance

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

| Index | ‘House’ | ‘dem’ | … | ‘zzz’ |
|---|---|---|---|---|
| 0 | 0*log(20799 / 100) | 1*log(20799 / 123) | … | 1*log(20799 / 521) |
| 1 | 0*log(20799 / 100) | 0*log(20799 / 100) | … | 1*log(20799 / 520) |
| … | … | … | … | … |
| 20799 | 0*log(20799 / 100) | 0*log(20799 / 100) | … | 1*log(20799 / 258) |

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

| | aaron | abandon | abandoned | abandoning | abbas | abbott | abc | abdel | abdullah | abe | ... | эти | это | этого | этой | этом | этот | является | على | في |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 20795 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20796 | 0.031752 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20797 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20798 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20799 | 0.000000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

20800 rows × 10000 columns

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

```
[('the', 91716),
 ('said', 79931),
 ('mr', 66051),
 ('trump', 43730),
 ('one', 38357),
 ('would', 37013),
 ('people', 34278),
 ('year', 30222),
 ('new', 29660),
 ('in', 26922)]
```

```
[('mr', 928.5925215826659),
 ('said', 862.4139927310313),
 ('the', 858.4163926949877),
 ('trump', 763.051045185191),
 ('clinton', 472.91698356645287),
 ('people', 429.43436830175136),
 ('would', 420.1967991746955),
 ('one', 413.1799007070279),
 ('president', 387.1987122968727),
 ('new', 382.69579627242337)]
```

Feature Extraction:

Bag of Words

N-grams

Tf - idf

# Baseline Models

```
models = {'Logistic Regression' : LogisticRegression(solver='liblinear'),
          'Random Forest' : RandomForestClassifier(n_estimators=10, max_depth=10),
          'Naieve Bayes' : GaussianNB(),
          'Support Vector Machine' : SVC(gamma='auto'),
          'K Nearest Neighbors' : KNeighborsClassifier(n_neighbors=10)}
```

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

```
========== Logistic Regression (on cv) ==========
Accuracy: 0.9545673076923077
Training Time: 6.4234230518341064 seconds

========== Logistic Regression (on tf) ==========
Accuracy: 0.9492788461538462
Training Time: 1.1744792461395264 seconds
```

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

```
========== Random Forest (on cv) ==========
Accuracy: 0.8764423076923077
Training Time: 3.203977346420288 seconds

========== Random Forest (on tf) ==========
Accuracy: 0.8403846153846154
Training Time: 3.1179282665252686 seconds
```

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

```
========== Naieve Bayes (on cv) ===========
Accuracy: 0.9098557692307693
Training Time: 4.190976142883301 seconds

========== Naieve Bayes (on tf) ===========
Accuracy: 0.8793269230769231
Training Time: 3.8143389225006104 seconds
```

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

```
========== Support Vector Machine (on cv) ==========
Accuracy: 0.9139423076923077
Training Time: 2315.0215451717377 seconds

========== Support Vector Machine (on tf) ==========
Accuracy: 0.49903846153846154
Training Time: 3326.895786046982 seconds
```

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

```
========== K Nearest Neighbors (on cv) ==========
Accuracy: 0.7555288461538462
Training Time: 12.049926042556763 seconds

========== K Nearest Neighbors (on tf) ==========
Accuracy: 0.5692307692307692
Training Time: 12.22933292388916 seconds
```

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

| Model | CV | TF |
|---|---|---|
| LR | 95% / 6.5s | 95% / 1.2s |
| RF | 88% / 3.2s | 88% / 3.2s |
| NB | 91% / 4.2s | 88% / 3.8s |
| SVM | 91% / 6.4hr | 50% / 9.2hr |
| KNN | 75% / 12s | 57% / 12s |

Classifiers:

Logistic Regression

Random Forest

Naive Bayes

SVM

KNN

# Baseline Models

http://127.0.0.1:5000/

Flask Web App:

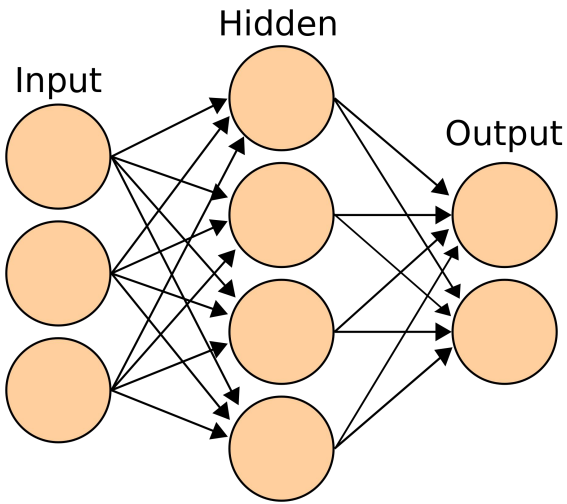
HTML

CSS (Bootstrap)

JS

Python

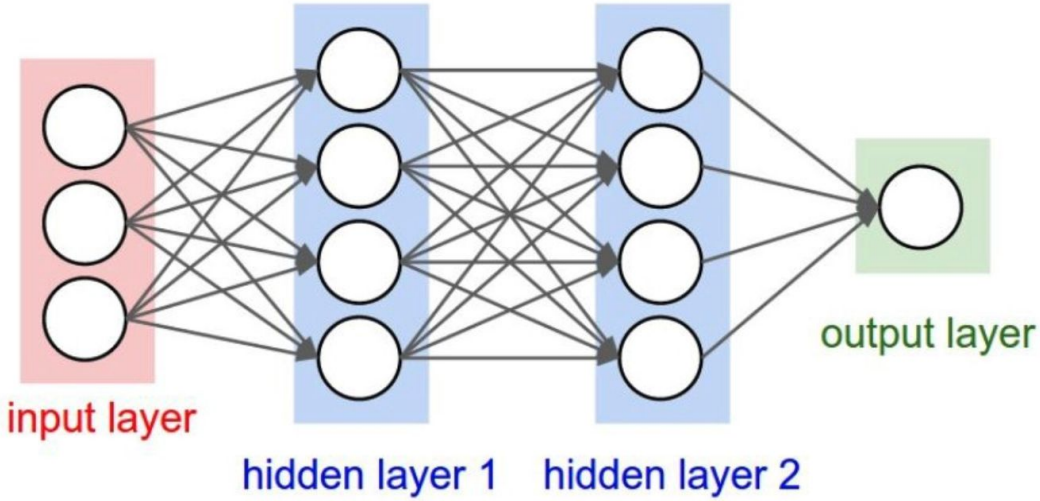
# DNN (Baseline)




## Artificial Neural Network

- Inspired by the biological neural networks that constitute animal brains.
- Formed by a collection of artificial neurons
- Neurons are organized in layers.

# DNN (Baseline)




## Deep Neural Network

- An artificial neural network (ANN) with multiple layers between the input and output layers
- Generate compositional models where the object is expressed as a layered composition of primitives.
- In this project, we consider Multiple Layer Perceptions (Feedforward networks)

# DNN (Baseline)

```
Epoch 1/10
16376/16376 [==============================] - 17s 1ms/sample - loss: 0.0189 - binary_accuracy: 0.9930
Epoch 2/10
16376/16376 [==============================] - 18s 1ms/sample - loss: 0.0211 - binary_accuracy: 0.9918
Epoch 3/10
16376/16376 [==============================] - 16s 1ms/sample - loss: 0.0157 - binary_accuracy: 0.9940
Epoch 4/10
16376/16376 [==============================] - 18s 1ms/sample - loss: 0.0087 - binary_accuracy: 0.9973
Epoch 5/10
16376/16376 [==============================] - 17s 1ms/sample - loss: 0.0075 - binary_accuracy: 0.9972
Epoch 6/10
16376/16376 [==============================] - 17s 1ms/sample - loss: 0.0099 - binary_accuracy: 0.9965
Epoch 7/10
16376/16376 [==============================] - 17s 1ms/sample - loss: 0.0081 - binary_accuracy: 0.9974
Epoch 8/10
16376/16376 [==============================] - 19s 1ms/sample - loss: 0.0039 - binary_accuracy: 0.9988
Epoch 9/10
16376/16376 [==============================] - 17s 1ms/sample - loss: 0.0063 - binary_accuracy: 0.9977
Epoch 10/10
16376/16376 [==============================] - 18s 1ms/sample - loss: 0.0050 - binary_accuracy: 0.9981
4094/4094 [==============================] - 1s 266us/sample - loss: 0.4479 - binary_accuracy: 0.9477
```

Results of using three hidden  layers

## Fake News detection using MLP

1. One word embedding Layer
2. Three fully connected hidden layers using Rectified Linear Unit Function (ReLU)
3. One output layer using sigmoid activation function

Binary_accuracy: 94.77%

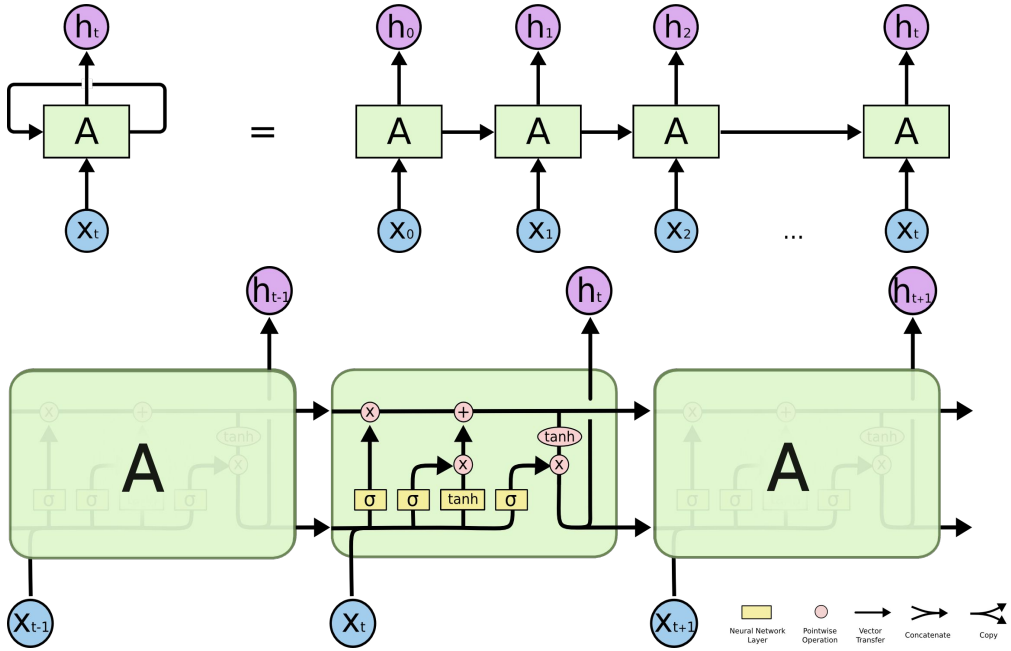
# RNN

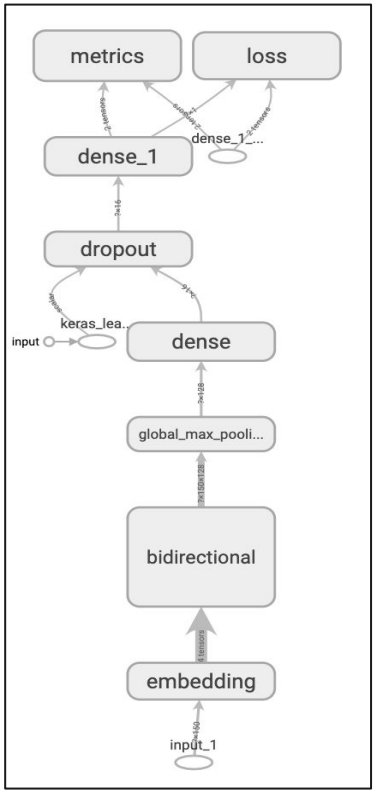
Applications: machine translation, image captioning, language modeling

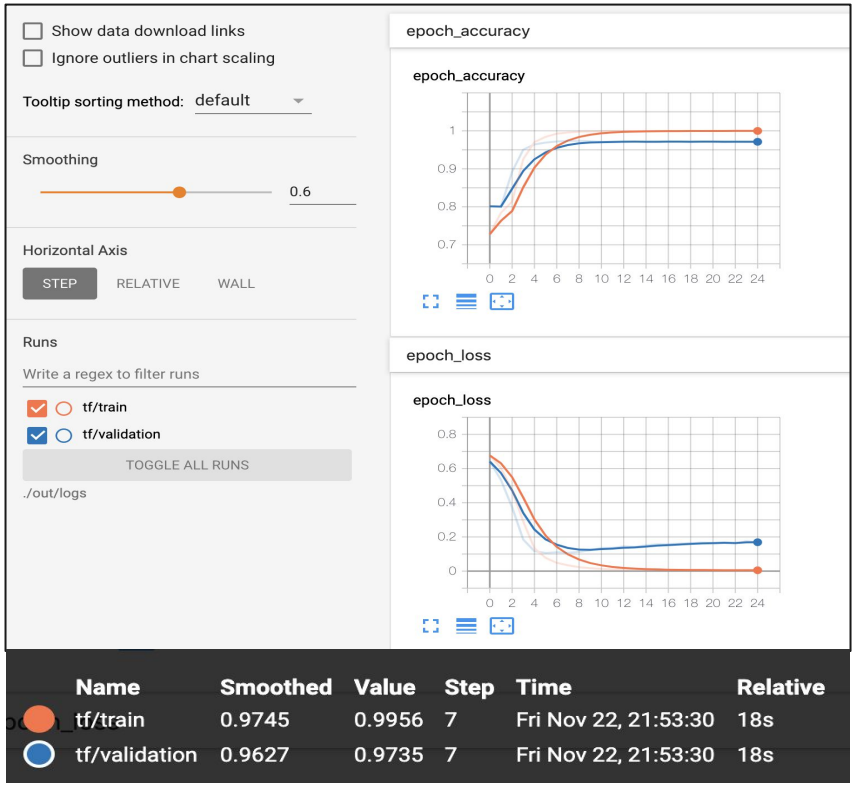
++pros: memorize the results of previous computations and use it in the current computation

--cons: vanishing gradient problem

- **LSTM (long short-term memory networks)[1]**
- ResNets (residual networks)[2]
- GRU (gated-recurrent networks)[3]





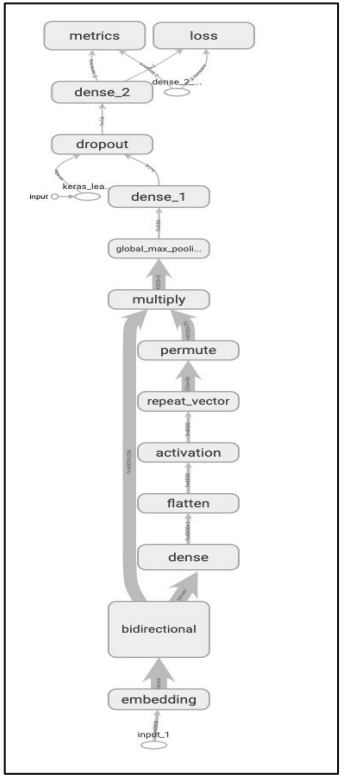



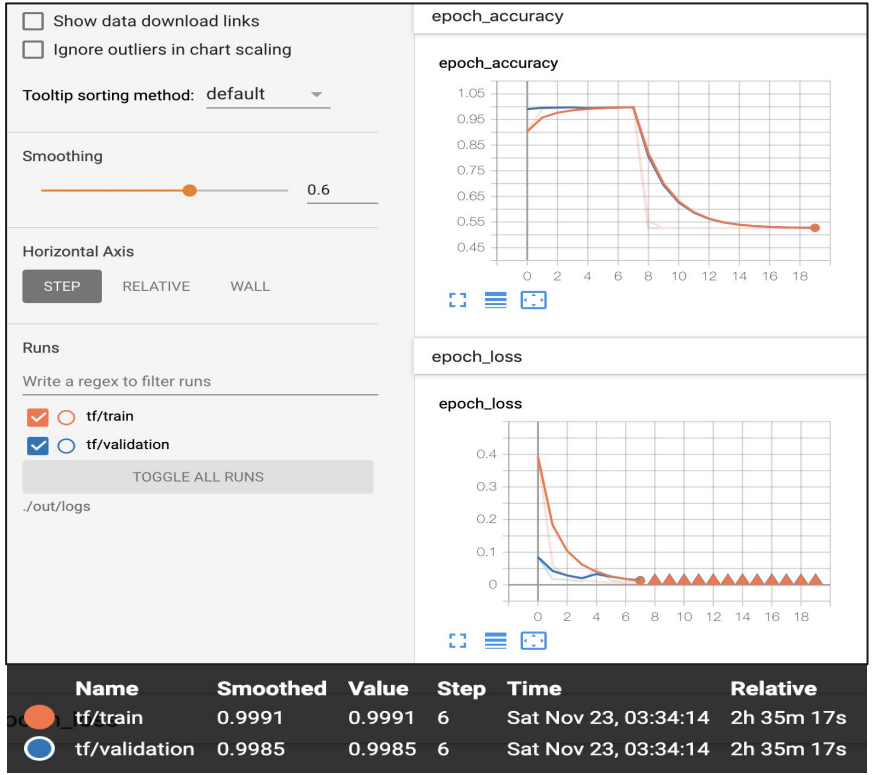

# LSTM

GPU: DUAL-RTX2080TI-O11G
TensorFlow 2.0

_emb_size = 128
_vocab_size = 10000
_seq_length = 4500

| | Accuracy |
|---|---|
| train | 0.9745 |
| validation | 0.9735 |




# LSTM + Attention

+accuracy improved
- time consuming

| | LSTM | Attention |
|---|---|---|
| train | 0.9745 | 0.9991 |
| val | 0.9735 | 0.9985 |

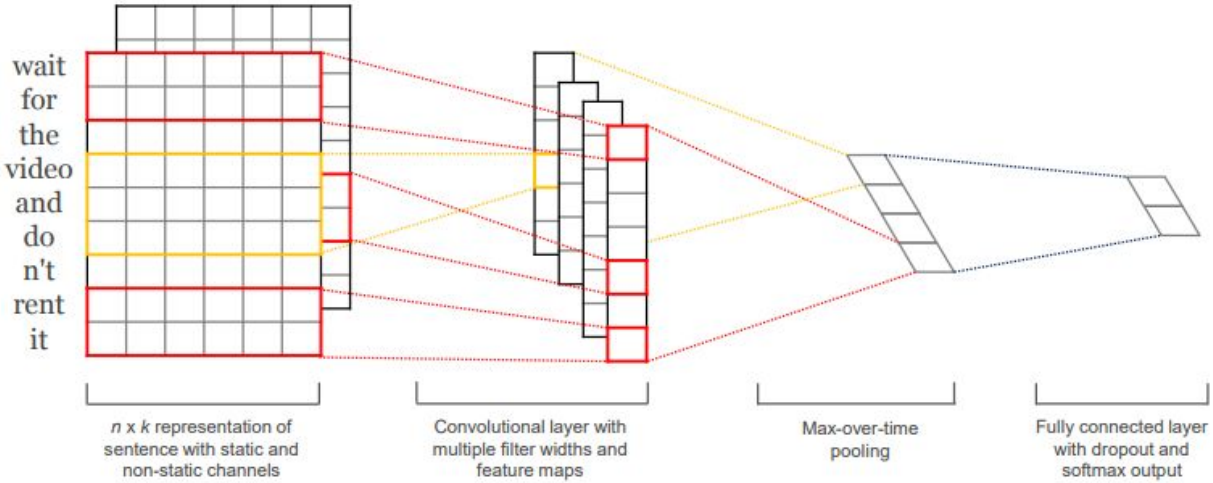
# Improvement for RNN

- Using pre-trained embeddings
- More STOA models, such us BERT(Bidirectional Encoder Representations from Transformers)
- Combination models, such us RNN combine CNN

Resources:
glove.840B.300d - https://nlp.stanford.edu/projects/glove/
paragram_300_sl999 - https://cogcomp.org/page/resource_view/106
wiki-news-300d-1M - https://fasttext.cc/docs/en/english-vectors.html

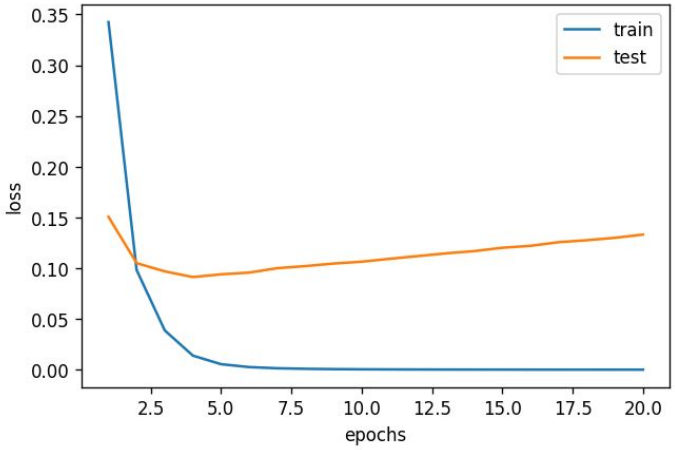
# CNN for Sentence Classification

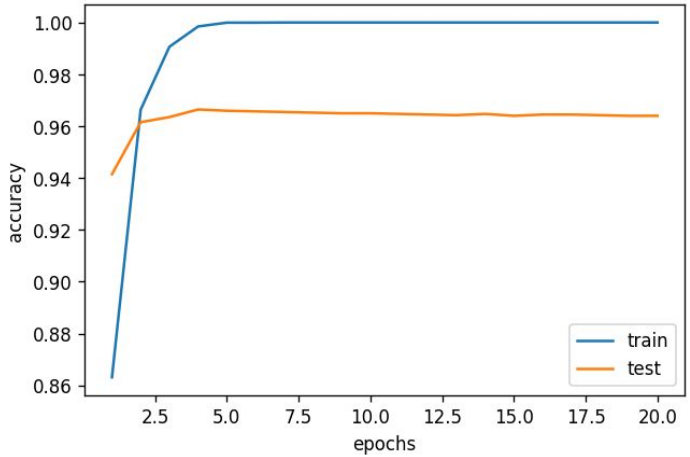
- Filters move in 1D space
- Preserve space information
- A global max pooling layer
- Dropout for regularization




Source: https://arxiv.org/pdf/1408.5882.pdf

# CNN Results



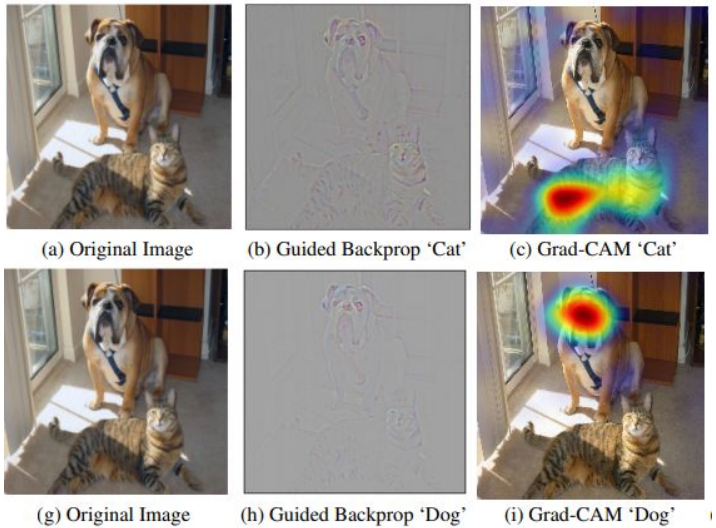

Training finished in 80s. Test accuracy: 0.967663

# Gradient-weighted Class Activation Mapping

- Global average of the gradients of class scores w.r.t feature maps.
- Generate CAM that has the same size as the feature map.
- Visualize as a coarse heat map

$$\alpha_k^c = \overbrace{\frac{1}{Z}\sum_i\sum_j}^{\text{global average pooling}} \underbrace{\frac{\partial y^c}{\partial A_{ij}^k}}_{\text{gradients via backprop}}$$

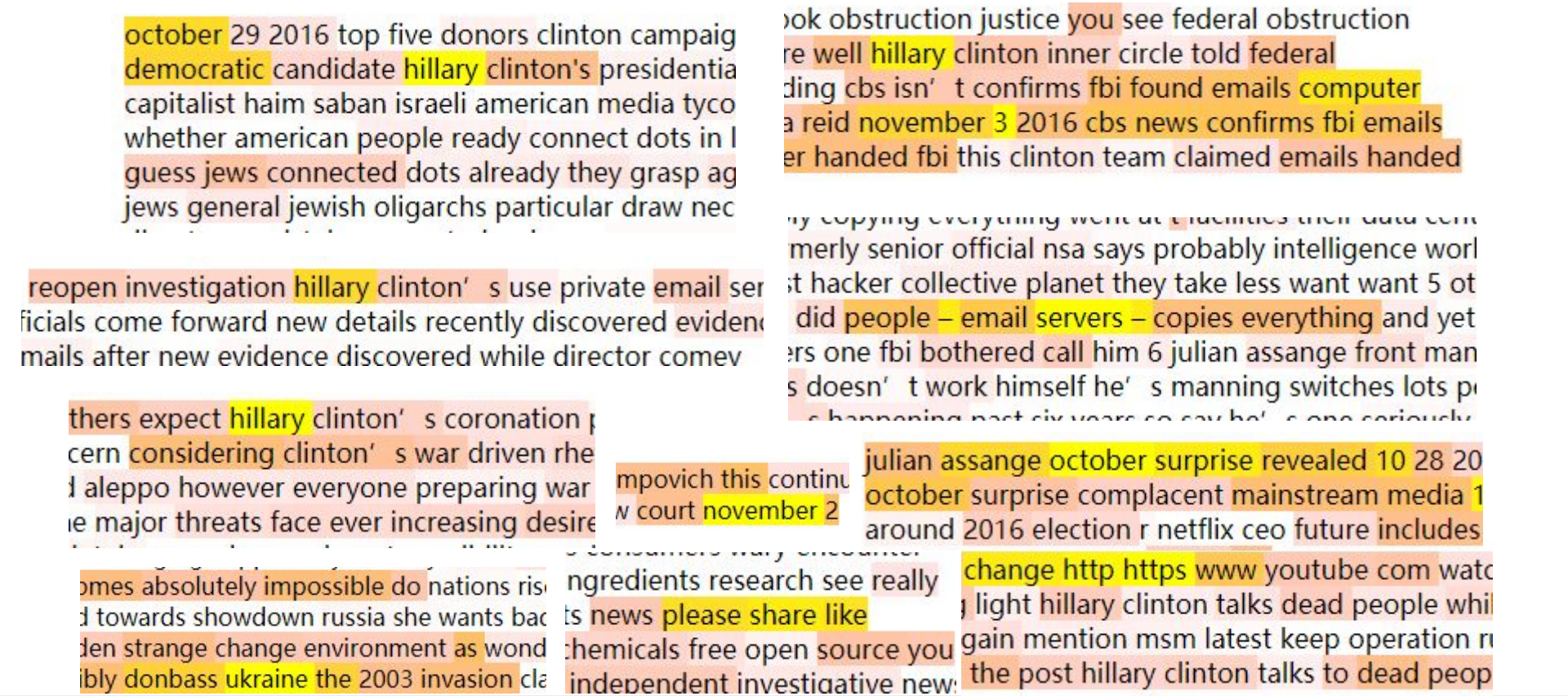
$$L_{\text{Grad-CAM}}^c = ReLU\underbrace{\left(\sum_k \alpha_k^c A^k\right)}_{\text{linear combination}}$$



(a) Original Image (b) Guided Backprop 'Cat' (c) Grad-CAM 'Cat'

(g) Original Image (h) Guided Backprop 'Dog' (i) Grad-CAM 'Dog'

Source: https://arxiv.org/pdf/1610.02391.pdf


october 29 2016 top five donors clinton campaig
democratic candidate hillary clinton's presidentia
capitalist haim saban israeli american media tyco
whether american people ready connect dots in
guess jews connected dots already they grasp ag
jews general jewish oligarchs particular draw nec
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# Conclusion

In this project, we:

1. Investigate different types of machine learning methods in fake news detection given the same fake news dataset.
2. Train a number of classical classification models as baseline model and compare their results.
3. Present three Deep learning methods for fake news detection and evaluate their performance.

# Q & A

# Thank You !