# Classifying Disaster Tweets with BERT

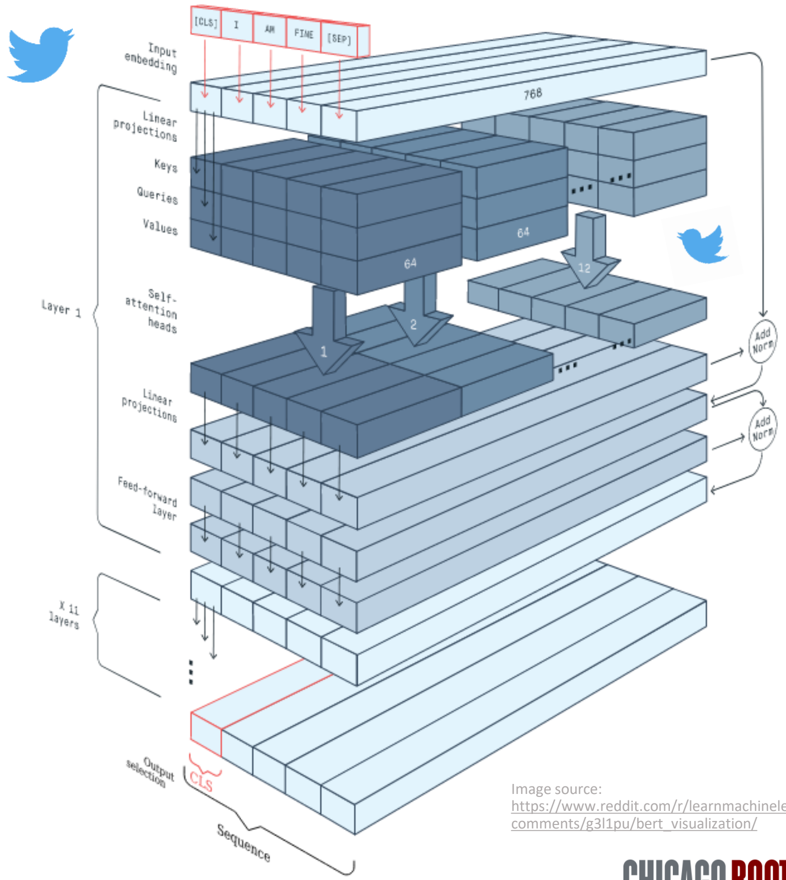



Figure 1. Structure of BERT

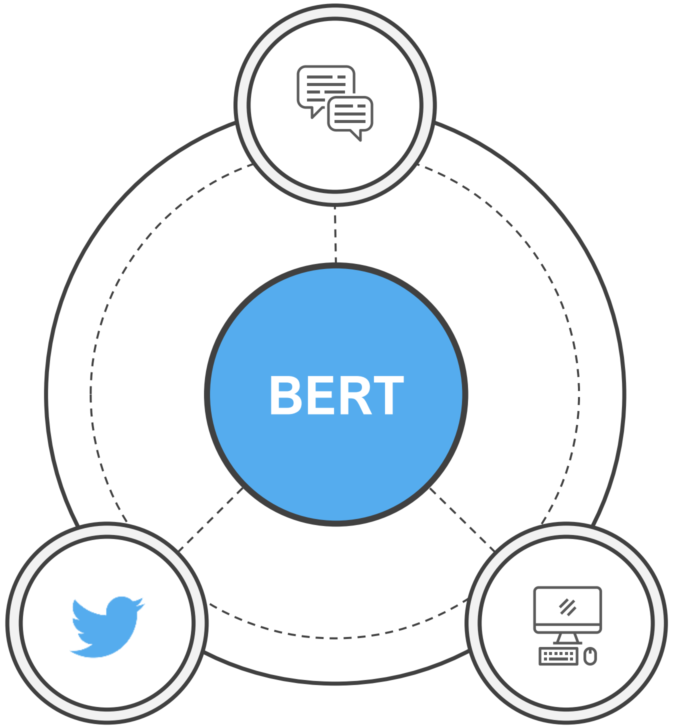
Image source:
https://www.reddit.com/r/learnmachinelearning/comments/g3l1pu/bert_visualization/

# Table Of Contents

# Overview

Social Networking Service

Realtime Communication




Natural Language Processing

Programmatically Monitor Content

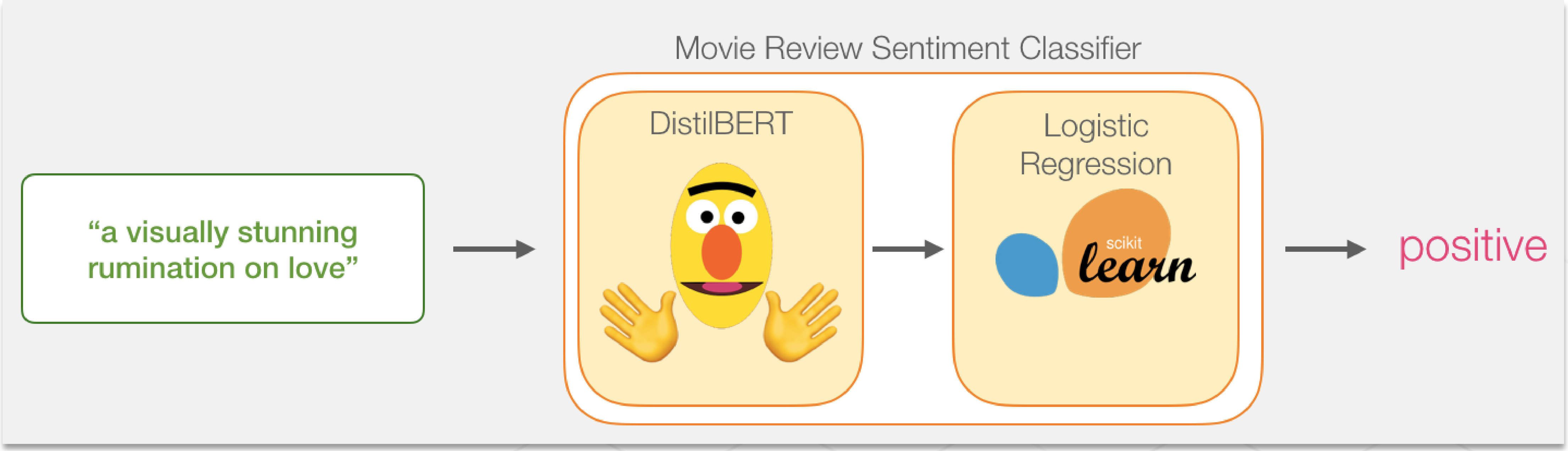
Machine Learning

Predictive Algorithm

# What is BERT?

- A Deep Neural Network (DNN) model

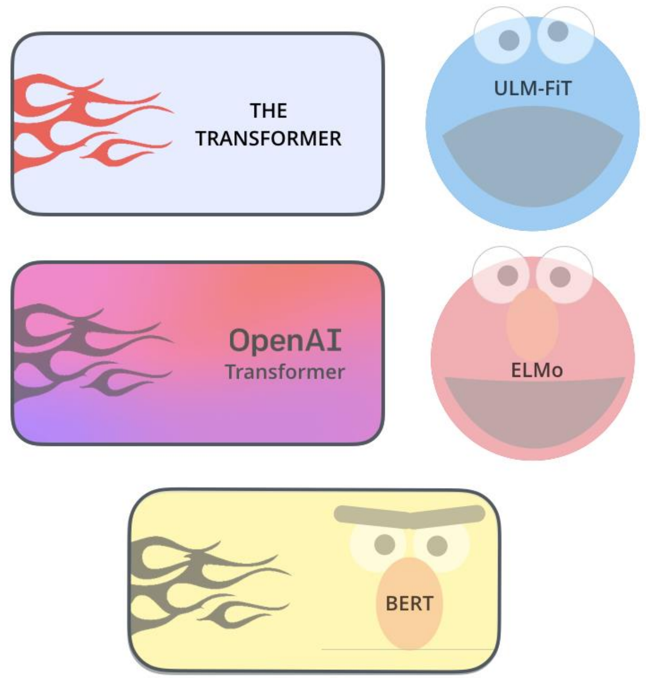
  2018 published Bidirectional Encoder Representations from Transformers (BERT)



# A brief history of NLP and ML

- **Bag of Words, TF, TF-IDF** naïve counts
- **Word2vec, GloVe** context-free embeddings
- **Transformer** encoder-decoder structure
- **ELMo** contextualized embeddings
- **OpenAI** fine-tuning pretrained models

"BERT does it all, and better!"



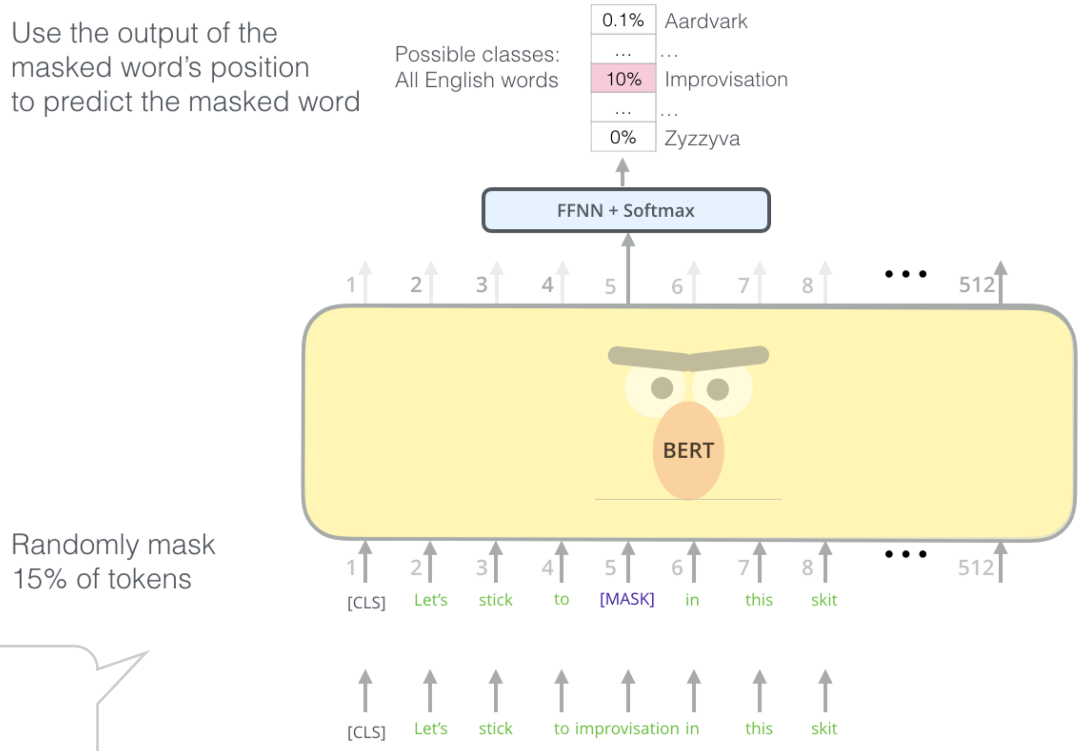
# Bidirectional Word Embeddings

- **Context Matters!**

  One of the main advantages of BERT

  Parallels with Convolutional Nets (fully connected)

"A New Age of Embedding"



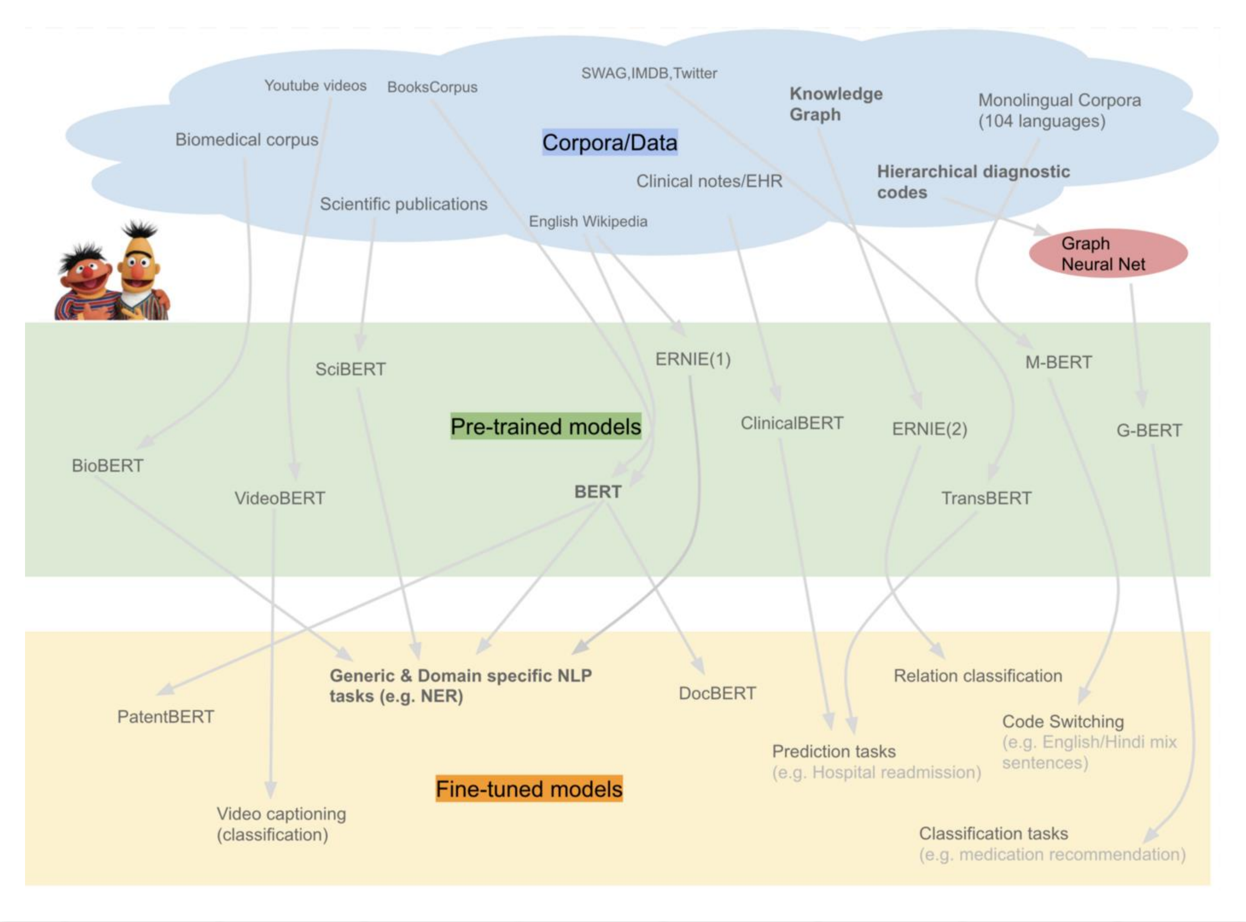
# Pretrained Models

- **Massive datasets**

  Pre-trained models used more than 10,000 books plus Wikipedia data

- **Superb efficiency**

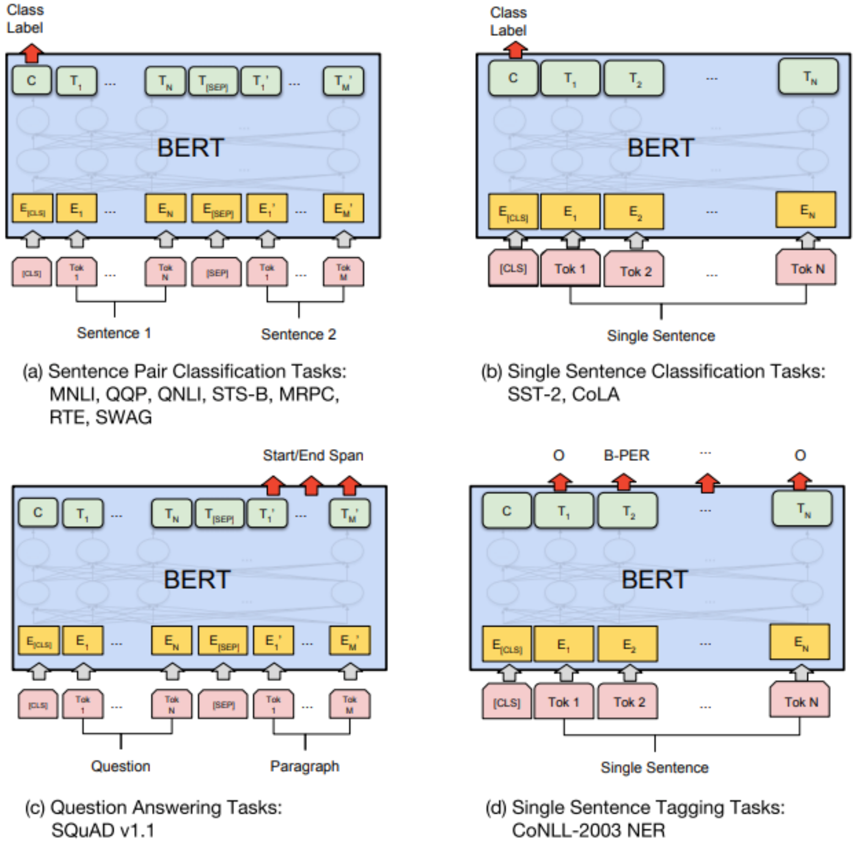
  BERT enables superior performance with minimal task-specific fine-tuning



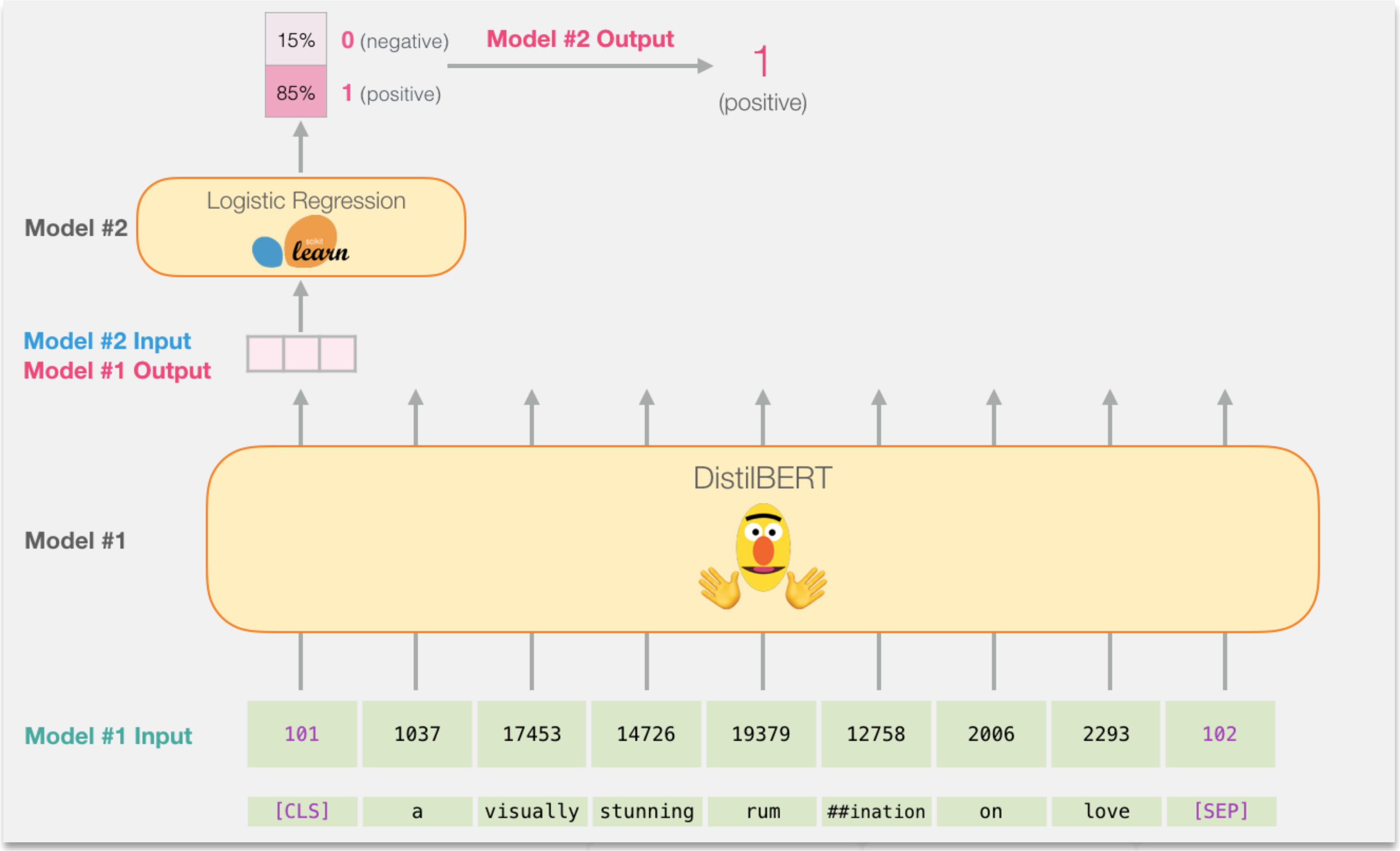
# Usage for different tasks

- **Numerous use cases**
  The authors of the original paper report a number of applications where BERT has powerful performance

- **Versatile machine**
  BERT can handle single sentence, sentence pairs, question answer pairs, and paragraphs.



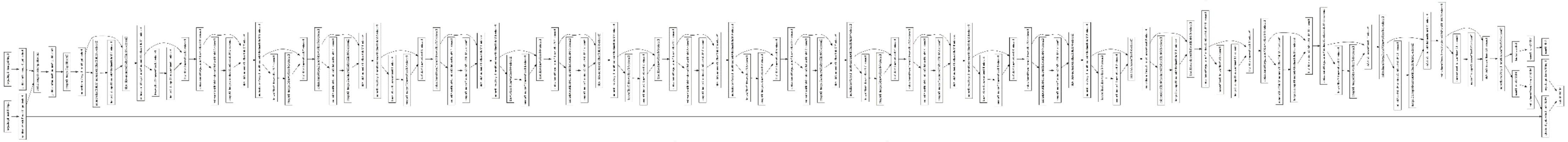
# Our task: Binary classification




"Classifying whether a disaster-related tweet is about a real disaster!"

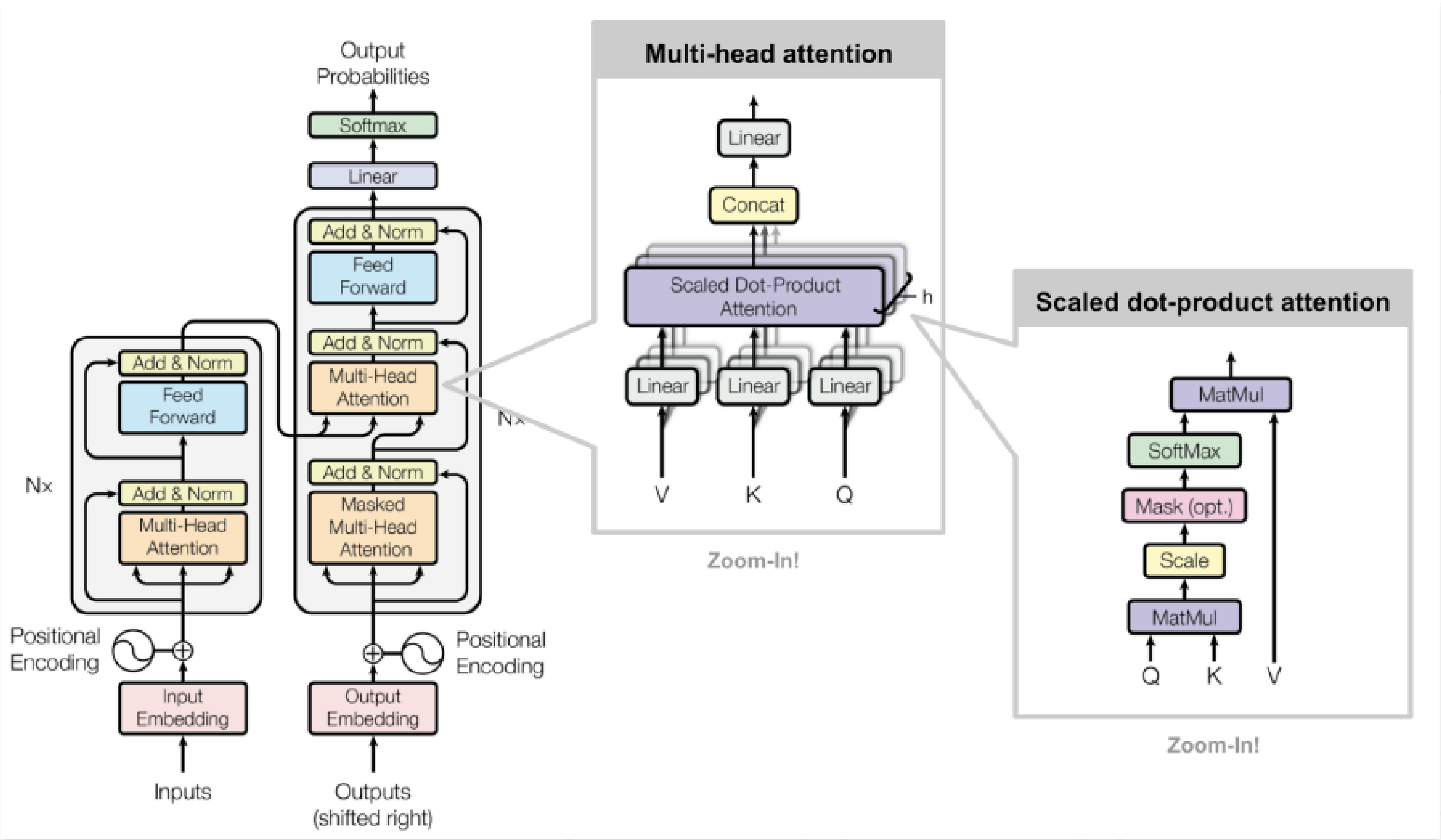
# The architecture

Below is not a DNA structure but BERT…



It takes time to understand… But we can take a glimpse at it!

# High level overview

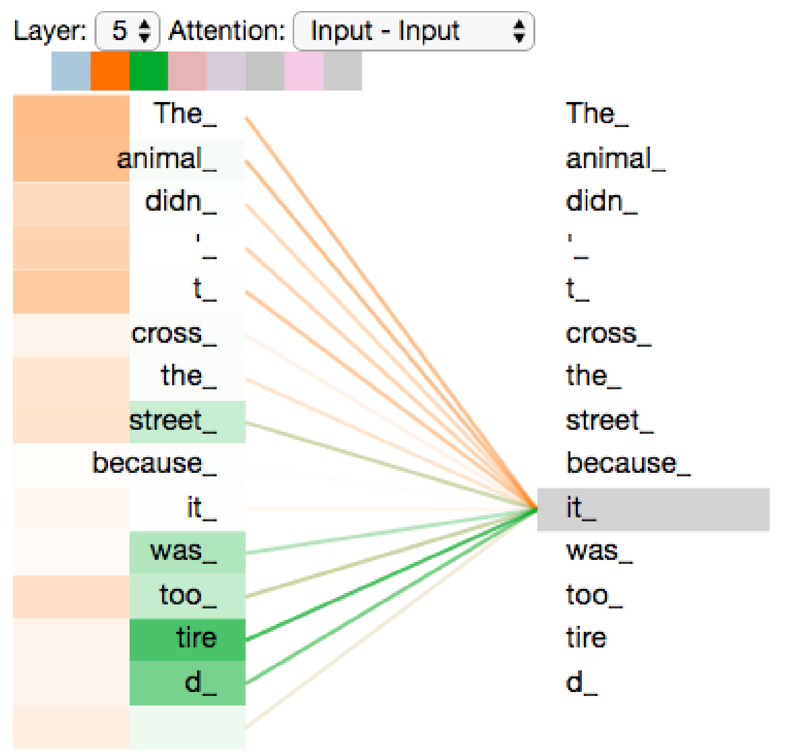


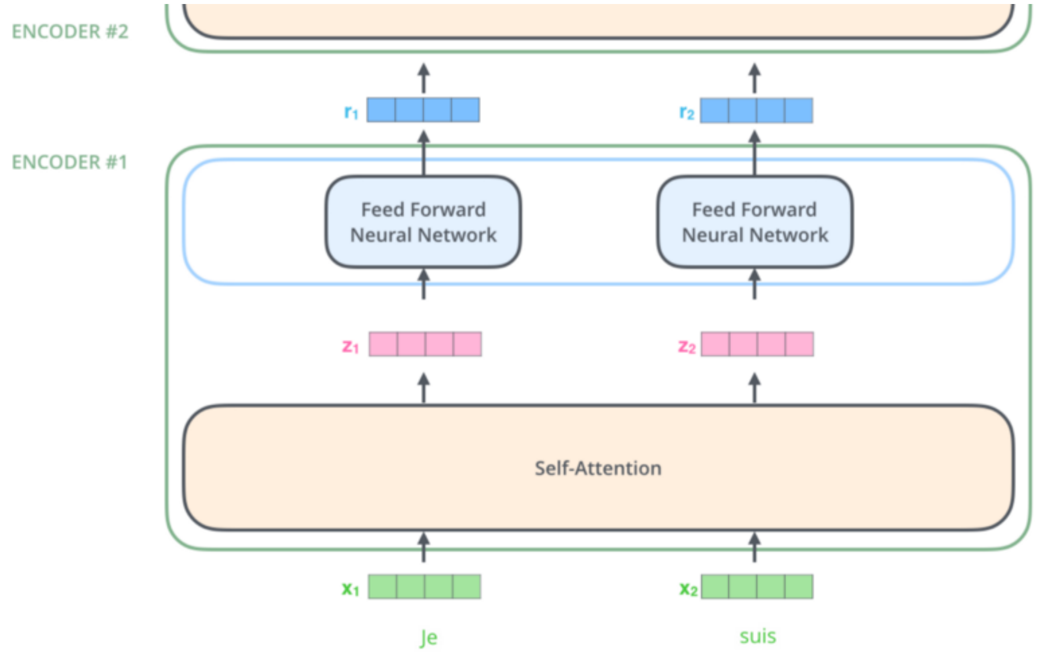

"It's a black box!"

# The encoder (1/3)

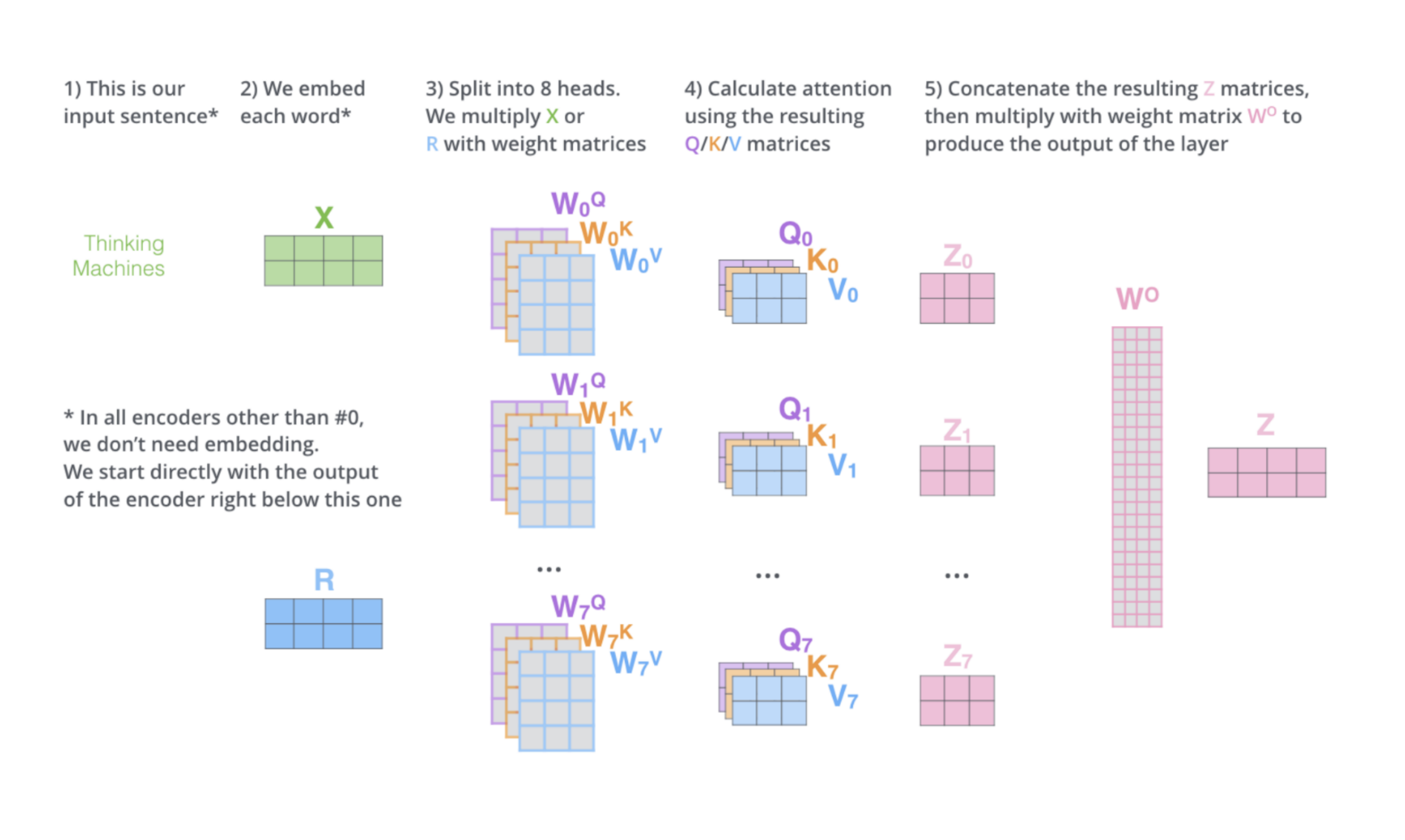
Multi-head Attention

Feed-forward NN



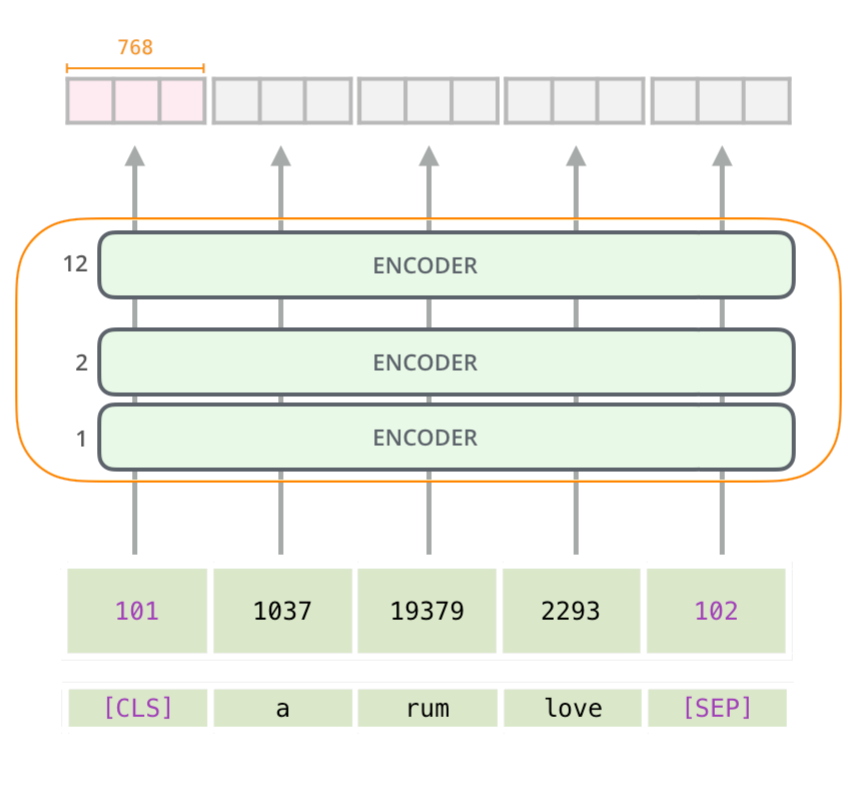



# The encoder (2/3)



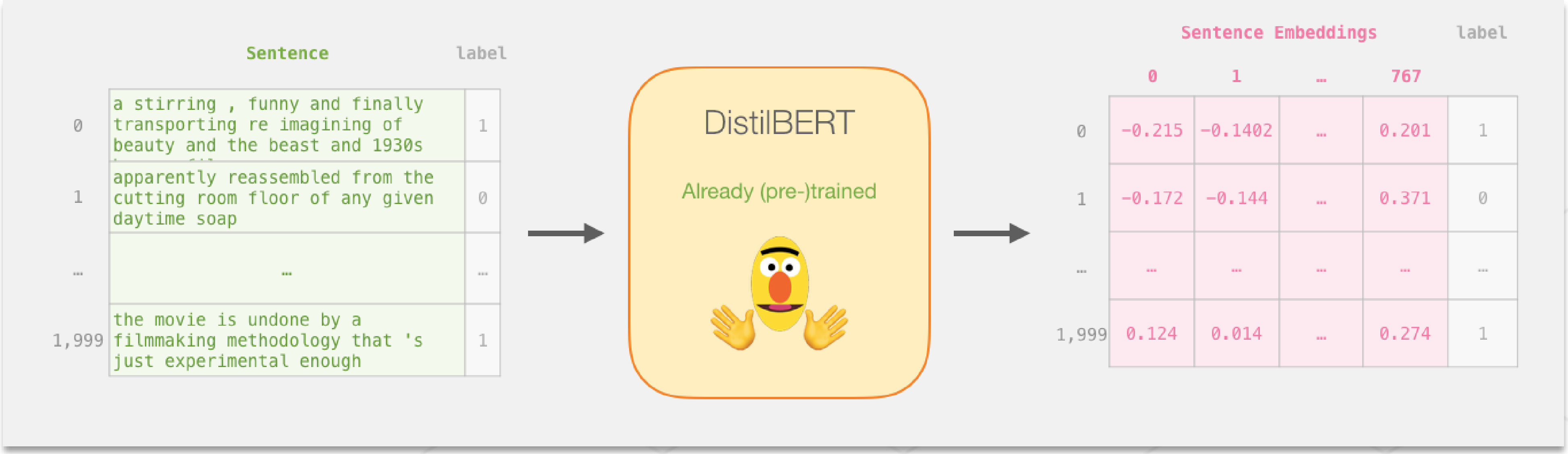

"Math behind it…"

Use Last-hidden layer

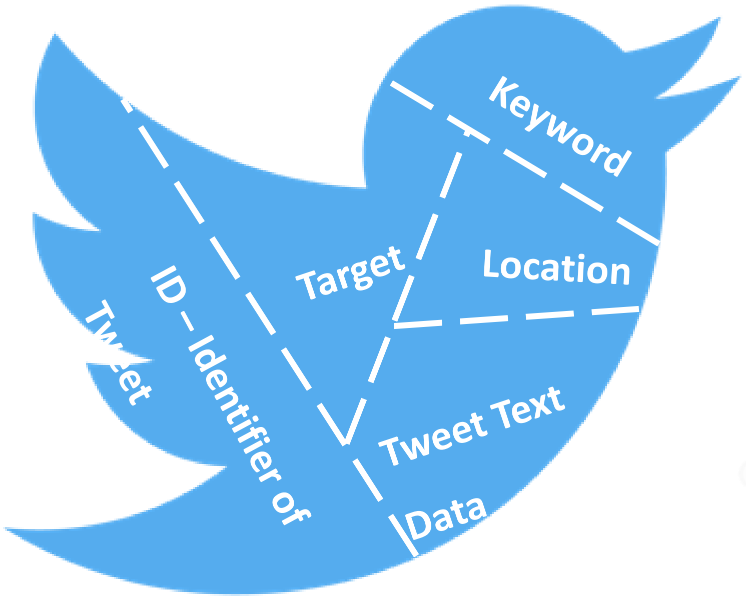


# The encoder (3/3)

- **Sentence embeddings can be retrieved from [CLS] token**
  Tweets are vectorized while carrying the contextual information. Hence, contextual embeddings
- **The embedding are fed into various ML algorithms to make predictions**
  Classification Tree, Random Forest, Logistic Regression



# Data Exploration




- **ID**

  Unique identifier for the tweet
- **Text**

  Text of the tweet
- **Location**

  Where the tweet was sent from (contains NA)
- **Keyword**

  Particular keyword from the tweet (contains NA)
- **Target**

  Indicate true disaster-related tweet

# Data (1/3) Original

| | keyword | location | text | target |
|---|---|---|---|---|
| 1 | NaN | NaN | Forest fire near La Ronge Sask. Canada | 1 |
| 2 | NaN | NaN | All residents asked to 'shelter in place' are ... | 1 |
| 3 | NaN | NaN | 13,000 people receive #wildfires evacuation or... | 1 |
| 4 | NaN | NaN | Just got sent this photo from Ruby #Alaska as ... | 1 |
| 5 | NaN | NaN | #RockyFire Update => California Hwy. 20 closed... | 1 |
| ... | ... | ... | ... | ... |
| 195 | ambulance | \|\| c h i c a g o \|\| | when you don't know which way an ambulance is ... | 1 |
| 196 | ambulance | NaN | #reuters Twelve feared killed in Pakistani air... | 1 |
| 197 | ambulance | L. A. | http://t.co/pWwpUm6RBj Twelve feared killed in... | 1 |
| 198 | ambulance | NaN | Why is there an ambulance right outside my work | 0 |
| 199 | ambulance | Canada | □ÛÏ@LeoBlakeCarter: This dog thinks he's an am... | 0 |

# Data (2/3) Tokenized and Normalized

| | keyword | location | text | tokenized | normalized |
|---|---|---|---|---|---|
| 1 | NaN | NaN | Forest fire near La Ronge Sask. Canada | ['Forest', 'fire', 'near', 'La', 'Ronge', 'Sas... | ['forest', 'fire', 'near', 'la', 'ronge', 'sas... |
| 2 | NaN | NaN | All residents asked to 'shelter in place' are ... | ['All', 'residents', 'asked', 'to', "'shelter"... | ['all', 'residents', 'asked', 'to', 'in', 'pla... |
| 3 | NaN | NaN | 13,000 people receive #wildfires evacuation or... | ['13,000', 'people', 'receive', '#', 'wildfire... | ['people', 'receive', 'wildfires', 'evacuation... |
| 4 | NaN | NaN | Just got sent this photo from Ruby #Alaska as ... | ['Just', 'got', 'sent', 'this', 'photo', 'from... | ['just', 'got', 'sent', 'this', 'photo', 'from... |
| 5 | NaN | NaN | #RockyFire Update => California Hwy. 20 closed... | ['#', 'RockyFire', 'Update', '=', '>', 'Califo... | ['rockyfire', 'update', 'california', 'hwy', '... |
| ... | ... | ... | ... | ... | ... |
| 195 | ambulance | \|\| c h i c a g o \|\| | when you don't know which way an ambulance is ... | ['when', 'you', 'do', "n't", 'know', 'which', ... | ['when', 'you', 'do', 'know', 'which', 'way', ... |
| 196 | ambulance | NaN | #reuters Twelve feared killed in Pakistani air... | ['#', 'reuters', 'Twelve', 'feared', 'killed',... | ['reuters', 'twelve', 'feared', 'killed', 'in'... |
| 197 | ambulance | L. A. | http://t.co/pWwpUm6RBj Twelve feared killed in... | ['http', ':', '//t.co/pWwpUm6RBj', 'Twelve', '... | ['http', 'twelve', 'feared', 'killed', 'in', '... |
| 198 | ambulance | NaN | Why is there an ambulance right outside my work | ['Why', 'is', 'there', 'an', 'ambulance', 'rig... | ['why', 'is', 'there', 'an', 'ambulance', 'rig... |
| 199 | ambulance | Canada | □ÛÏ@LeoBlakeCarter: This dog thinks he's an am... | ['\x89ÛÏ', '@', 'LeoBlakeCarter', ':', 'This',... | ['leoblakecarter', 'this', 'dog', 'thinks', 'h... |

# Data (3/3) BERT Embedding, Vectorized

| | label | text | V0 | V1 | V2 | V3 | V764 | V765 | V766 | V767 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Forest fire near La Ronge Sask. Canada | -0.221553 | 0.105736 | 0.177232 | -0.060106 | -0.112760 | -0.048379 | 0.136526 | 0.247243 |
| 2 | 1 | All residents asked to 'shelter in place' are ... | -0.306347 | -0.045762 | 0.105919 | -0.162701 | -0.142231 | 0.002799 | 0.350246 | 0.166709 |
| 3 | 1 | 13,000 people receive #wildfires evacuation or... | -0.198977 | 0.059032 | 0.068434 | -0.208566 | 0.027611 | 0.014557 | 0.229373 | 0.303111 |
| 4 | 1 | Just got sent this photo from Ruby #Alaska as ... | -0.204478 | -0.069526 | 0.100186 | -0.165095 | -0.014447 | -0.010891 | 0.234791 | 0.152992 |
| 5 | 1 | #RockyFire Update => California Hwy. 20 closed... | -0.236724 | -0.057379 | 0.109873 | -0.124354 | -0.037461 | 0.132887 | 0.206636 | 0.252258 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 195 | 1 | when you don't know which way an ambulance is ... | -0.255051 | -0.122965 | 0.065260 | -0.267028 | 0.018411 | -0.021807 | 0.364001 | 0.285695 |
| 196 | 1 | #reuters Twelve feared killed in Pakistani air... | -0.266950 | -0.270678 | 0.202017 | -0.085696 | 0.052191 | 0.054019 | 0.258357 | 0.092139 |
| 197 | 1 | http://t.co/pWwpUm6RBj Twelve feared killed in... | -0.241344 | -0.300067 | 0.194483 | -0.069829 | 0.051480 | 0.097453 | 0.423019 | -0.003391 |
| 198 | 0 | Why is there an ambulance right outside my work | -0.260271 | -0.088422 | -0.099738 | -0.424868 | 0.139882 | -0.041099 | 0.529022 | 0.386493 |
| 199 | 0 | □ÛÏ@LeoBlakeCarter: This dog thinks he's an am... | -0.244549 | -0.087695 | 0.099643 | -0.156994 | -0.052463 | -0.012890 | 0.336068 | 0.125962 |

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# Model comparison

- Model Selection Criterion

  Hyperparameter tuning and 5-fold CV, 1SE deviance

- Performance Measure

  Confusion Matrix, F1-score

- Algorithms

  Distil BERT – Classification Tree

  Distil BERT – Random Forest

  Distil BERT – Logistic Regression

  BERT-base Binary Classifier

# Decision Tree

| | Prediction T | Prediction F | |
|---|---|---|---|
| **Actual T** | 751 | 651 | Sensitivity = 0.536 |
| **Actual F** | 704 | 1,157 | Specificity = 0.622 |
| | Precision = 0.516 | Neg-preci = 0.640 | **Accuracy = 0.578** |
| | | Total obs. = 3,263 | **F1 score = 0.526** |

# Random Forest

| | Prediction T | Prediction F | |
|---|---|---|---|
| **Actual T** | 868 | 534 | Sensitivity = 0.619 |
| **Actual F** | 382 | 1,479 | Specificity = 0.795 |
| | Precision = 0.694 | Neg-preci = 0.630 | Accuracy = 0.715 |
| | | Total obs. = 3,263 | F1 score = 0.655 |

# Logistic Regression

| | Predict T | Predict F | |
|---|---|---|---|
| **Actual T** | 766 | 636 | Sensitivity = 0.546 |
| **Actual F** | 439 | 1,422 | Specificity = 0.764 |
| | Precision = 0.636 | Neg-preci = 0.691 | Accuracy = 0.663 |
| | | Total obs. = 3,263 | F1 score = 0.588 |

# BERT Binary Classifier

| | Predict T | Predict F | |
|---|---|---|---|
| **Actual T** | 959 | 443 | Sensitivity = 0.684 |
| **Actual F** | 196 | 1,665 | Specificity = 0.895 |
| | Precision = 0.830 | Neg-preci = 0.790 | **Accuracy = 0.810** |
| | | Total obs. = 3,263 | **F1 score = 0.750** |

Comments

- The outcome is based on Gelu activation and logit prediction
- Due to the hardware limitations, BERT-base was only trained 1 epoch while BERT-large was unable to be fine-tuned.

# Final comments

- Model Performances

  BERT reported both the lowest type I and type II errors and outperformed the other models in every criteria, leading the second-best model by

  - 9.5pp in overall accuracy, reporting 81%
  - 0.095 in F-1 score, reporting 0.750

- Improvements to be made

  - start with the right device and train BERT-large
  - scrape more data from twitter

- A way to the future: Human first-AI

  One of the implications for this project is a potential automated monitoring system that could be used as an alert system. And I would like to suggest that the alert system can be perfected with human touch.

# References

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  https://mlfromscratch.com/activation-functions-explained/#/
- Bert for Beginners (easy read)
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