

# Fake news: an algorithmic perspective on fact-checking

Martijn B.J. Schouten  
11295562

Bachelor thesis  
Credits: 12 EC

Bachelor's degree Information Science

University of Amsterdam  
Faculty of Science  
Science Park 904  
1098 XH Amsterdam

*Supervisor*  
Dr. M. J. Marx

ILPS, IvI  
Faculty of Science  
University of Amsterdam  
Science Park 904  
1098 XH Amsterdam

2019-06

Add a  
final date

20

## Abstract

21

Add an  
abstract

22	<b>Contents</b>	
23	<b>1 Introduction</b>	<b>4</b>
24	<b>2 Related Work</b>	<b>5</b>
25	2.1 Automatic fake news detection . . . . .	5
26	2.2 Pooling . . . . .	5
27	2.3 Padding . . . . .	6
28	2.4 Neural text classifiers . . . . .	6
29	<b>3 Methodology</b>	<b>6</b>
30	3.1 Description of the data . . . . .	6
31	3.2 Data preprocessing and cleaning . . . . .	8
32	3.2.1 Filtering statements . . . . .	8
33	3.2.2 Reducing labels . . . . .	8
34	3.3 Methods . . . . .	9
35	3.3.1 RQ1 . . . . .	9
36	3.3.2 RQ2 . . . . .	9
37	3.3.3 RQ3 . . . . .	9
38	<b>4 Evaluation</b>	<b>9</b>
39	4.1 RQ1 . . . . .	9
40	4.2 RQ2 . . . . .	9
41	4.3 RQ3 . . . . .	10
42	<b>5 Conclusions</b>	<b>11</b>
43	5.1 Acknowledgements . . . . .	11

# 1 Introduction

The ability to broadcast information on a large scale has been in the hands of large publishing organizations in the pre-Internet era, but nowadays everyone can share news via social media [7]. This introduces risks on validity and authenticity of news, as social media and digital platforms can speed up the spread of falsehoods without much effort from the author [5].

As a matter of fact, 63% of adults in the United States prefer to read their news on the Internet. Young adults take the lead: 76% of adults between the ages 18 and 49 get their primary news consumption via the web, compared to just 43% for adults of 50 years and older [13]. As time passes by, social media is slowly becoming the primary source of news for more and more people.

The main danger of this development is that human perception is often skewed with regards to objectivity of facts. Naïve realism let consumers of news believe that their perception is right, while other's perceptions are uninformed. Furthermore, confirmation bias results in consumers preferring information that confirms beliefs they already have [19]. This makes consumers vulnerable for the spread of misinformation or fake news.

According to the European Commission, "*disinformation - or fake news - consists of verifiably false or misleading information that is created, presented and disseminated for economic gain or to intentionally deceive the public, and may cause public harm*" [5]. The answer to the problem of fake news as of recently has been to manually fact-check statements on validity, but, as Shu et al. underlines, one of the downsides to this approach is that fake news typically relates to newly emerging, time-critical events. This means the real news may not be fully verified by proper knowledge bases due to a lack of contradicting claims [19]. An automated approach would both help in solving the problem of human subjectivity and the speed at which false information is spread in the current news spreading landscape. Furthermore, such an approach can help human fact-checking by targetting statements that are most likely to be false.

Natural language processing has been in rapid development over the past years. With the releases of OpenAI's GPT-2 model in February of this year and Google's BERT in the autumn of 2018, state-of-the-art pre-trained textual embedding techniques have shown promising results on various classification tasks [15][6]. Although fake news classification has been attempted before [21][9], performance has been rather low. However, these new pre-trained textual embeddings have not yet been used in the fight against disinformation.

This thesis is focussed on the following research question: *what is the performance of combinations of pre-trained embedding techniques with machine learning algorithms when classifying fake news?* This main question will be answered through the results of the following subquestions:

**RQ1** Which way of pooling vectors to a fixed length works best for classifying fake news?

**RQ2** At what padding sequence length do neural networks hold the highest accuracy when classifying fake news?

**RQ3** How well do neural network classification architectures classify fake news compared to non-neural classification algorithms?

## 91 2 Related Work

### 92 2.1 Automatic fake news detection

93 There have been several attempts in the past to create classifiers for automatic  
94 detection of lies and fake news. Wang used both linear and neural classifiers to  
95 classify statements from the Liar dataset into 6 possible gradations of truthfulness.  
96 Furthermore, he added speaker metadata to improve the result of his classifications.  
97 Both with and without introducing speaker metadata, the best performing  
98 architecture was found to be a convolutional neural network. With an accuracy  
99 of 27% without, and 27,4% with metadata on the test set, Wang was able to  
100 perform 6,2% and 6,6% better than the majority baseline of 20,8% [21].

101 From the same dataset, Khurana extracted linguistic features such as n-  
102 grams, sentiment, number of capital letters and POS tags to classify the data  
103 into 3 labels instead of the original 6 labels. For classification, she used a set of  
104 non-neural classifiers. Her best performing classifier, using gradient boosting,  
105 obtained an accuracy of 49,03%, which performed around 5% better than the  
106 majority baseline of 44,28% [9].

107 The British factchecking organization Full Fact has developed an architecture  
108 that is able to monitor and factcheck statements from the British Parliament  
109 and major media outlets in the United Kingdom. It can automatically factcheck  
110 the accuracy of statistical claims, for example [3]. For detecting factual claims  
111 from texts, the organization uses InferSent, which is a way of transfer learning  
112 that has been proved to perform well for the use case of Full Fact [11].

113 Various tools with regards to fake news detection are also available. Faker  
114 Fact is a tool which can classify texts into a set of categories ranging from satire  
115 to agenda-driven, the former identifying humorous intent, the latter identifying  
116 manipulation [1]. Hoaxy, on the other hand, allows for the visualization of  
117 unverified claims through Twitter networks [17].

### 118 2.2 Pooling

119 Linear classifiers need data in a two-dimensional shape to be able to perform  
120 calculations. In the case of raw text data, sentences in the dataset have variable  
121 word lengths, resulting in a different vector length when turning the text into a  
122 vector representation. To turn the vector representations into a uniform length,  
123 we can either cut off the vectors at a fixed length (*padding*), or we can perform  
124 calculations to reduce the length of the vectors (*pooling*).

125 In computer vision, feature pooling is used to reduce noise in data. The  
126 goal of this step is to transform joint feature representations into a new, more  
127 usable one that preserves important information while discarding irrelevant  
128 details. Pooling techniques such as max pooling and average pooling perform  
129 mathematical operations to reduce several numbers into one [4]. In the case of  
130 transforming the shape of the data, we can reduce vectors to the smallest vector  
131 in the dataset to create a uniform shape.

132 Scherer et al. compared performance of two pooling operations on a convolutional  
133 neural network architecture. The first pooling method extracted maximums  
134 and the second one was primarily based on working with averages. They have  
135 shown that a max pooling operation is vastly superior for capturing invariances  
136 in image-like data [16].

137 Shen et al. noted that in text classification, only a small number of key  
138 words contribute to the final prediction. As a result, simple pooling operations  
139 are surprisingly effective for representing documents [18]. Lai et al., Hu et al.  
140 and Zhang et al. use a max pooling layer in a (recurrent) convolutional neural  
141 network for identifying key features in text classification [12][8][23]. In the case  
142 of text classification, max pooling strategies seem to be the most popular.

## 143 2.3 Padding

144 When padding a sequence, a list of sequences is transformed to a specific length.  
145 Sequences longer than the desired length will be truncated to fit the requirement,  
146 while sequences shorter than the desired length will be padded by a specified  
147 value [2]. To fill the sequences, a value of zero is often used. Hu et al. also use  
148 zero values for padding their sequences [8].

149 Apart from controlling the size of the feature dimension, padding has other  
150 uses as well. Simard et al. make use of sequence padding for convolutional  
151 neural networks to center feature units, and concluded it did not impact the  
152 performance of the classifier significantly [20]. Wen et al. apply padding to  
153 convolutional network models to prevent dimension loss [22].

## 154 2.4 Neural text classifiers

155 Wang has shown that neural networks perform slightly better on classifying fake  
156 news than linear classifiers. In his research, he compared accuracies on support  
157 vector machines, logistic regressions, bidirectional LSTMs and convolutional  
158 neural networks with each other. With his 6 label classification, his support  
159 vector machine implementation was the best performing linear classifier, but  
160 the performance was slightly worse than the best performing neural network  
161 (25,8% for the former, and 26% for the latter) [21].

162 Wang used two neural network architectures both well known for their  
163 robustness and performance when it comes to text classification. The first  
164 model, the bidirectional Long Short Term Memory (LSTM) networks, are specifically  
165 tailored at keeping track of information for a long period of time. This makes  
166 those models able to keep track of the context in a more intelligent way when  
167 compared to a standard non-neural classification algorithm [14].

168 The second architecture, the convolutional neural network, apply a set of  
169 filters in its layers to local features. These models are shown to be effective in  
170 numerous natural language processing applications, such as semantic parsing,  
171 search query retrieval, sentence modeling and other traditional NLP tasks [10].

## 172 3 Methodology

### 173 3.1 Description of the data

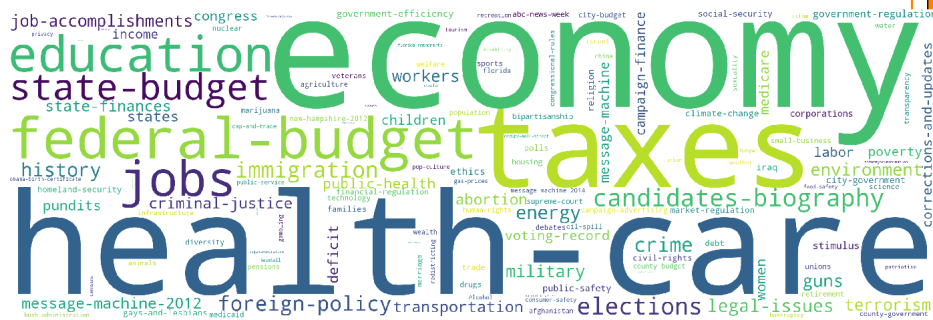
174 For classifying fake news, Wang's Liar dataset will be used [21]. The Liar  
175 dataset contains 12.791 short statements from Politifact.com, which are labeled  
176 manually by a Politifact.com editor on truthfulness. The statements are an  
177 average of 18 tokens long, and the topics vary from different political subjects,  
178 as can be seen in figure 1. Truthfulness is evaluated by assigning one of 6 labels,

Check  
whether  
this  
number  
is still  
correct

id	11044.json
label	pants-fire
statement	The Mexican government forces many bad people into our country.
subjects	foreign-policy,immigration
speaker	donald-trump
speaker_job	President-Elect
state	New York
party	republican
context	an interview with NBC's Katy Tur
mostly_true_count	37
half_true_count	51
barely_true_count	63
false_count	114
pants_on_fire_count	61

Table 1: An example entry in the Liar dataset.

179 ranging from *pants-on-fire* to *true*. The distribution of statements across the  
180 original 6 labels can be seen in figure 2.



Check  
whether  
this  
number  
is still  
correct

Figure 1: An overview of all statement topics in the Liar dataset.

181 For each statement, the dataset contains an id, a label, a subject, a speaker,  
182 the function title of the speaker, the affiliated state and political affiliation, the  
183 context of the statement and a vector with a truthfulness history. An example  
184 of such a data entry can be seen in table 1. Wang introduced this truthfulness  
185 history to boost the prediction scores, as speakers with a track record of lying  
186 are expected to have a lower chance of speaking the truth when classifying  
187 new statements. However, for our application we are only interested in the  
188 statement itself and its corresponding label. Due to cheapness and spreadability,  
189 a large amount of fake news is spread over social media [19]. This means  
190 author information and metadata will not readily be available in real world  
191 circumstances.

Check  
whether  
this  
number  
is still  
correct

192 The original dataset has been split beforehand into a test, train and validation  
193 set. The train set contains 80% of the total amount of statements, while the  
194 test and validation set both contain approximately 10% of the statements.

6 labels	3 labels	2 labels
true (16.1%)	true (35,3%)	true (55,8%)
mostly-true (19.2%)		
half-true (20.5%)	half-true (20.5%)	
barely-true (16.4%)	false (44,19%)	false (44,19%)
false (19.6%)		
pants-fire (8.19%)		

Table 2: Distribution of labels from the original label distribution when reducing the amount of labels.

## 3.2 Data preprocessing and cleaning

### 3.2.1 Filtering statements

The original dataset contained statements ranging from 1 sentence to 19. On closer inspection of statements with the high amounts of sentences, it was found that not all statements were processed from source files into dataframes correctly. As a result, records of some different statements were joined together, forming a single string. To combat this, the following regular expression was used to filter those statements out:

```
\\.json\\t(mostly-true|true|half-true|false|barely-true|pants-fire)\\
```

After applying this regular expression, the total amount of sentences in the statements were reduced from a maximum of 19 to a maximum of 11.

### 3.2.2 Reducing labels

Wang’s main objective was to classify fake news into a fine-grained category of fakeness [21]. For our main research question, we aim to predict whether the statements are fake news or not. Because of this, for the rest of this research, the prediction labels from the original dataset will be reduced from 6 labels to 2 labels, according to the recoding schema used by Khurana [9]. The 6 labels are reduced to the following 3 labels: **true**, **half-true** and **false**.



### 215 3.3 Methods

#### 216 3.3.1 RQ1

#### 217 3.3.2 RQ2

#### 218 3.3.3 RQ3

## 219 4 Evaluation

### 220 4.1 RQ1

221 **Which way of pooling vectors to a fixed length works best for classifying**  
222 **fake news?**

223 The answer to this question will be given by comparing accuracy of a logistic  
224 regression with different pooling strategies (max, min, average).

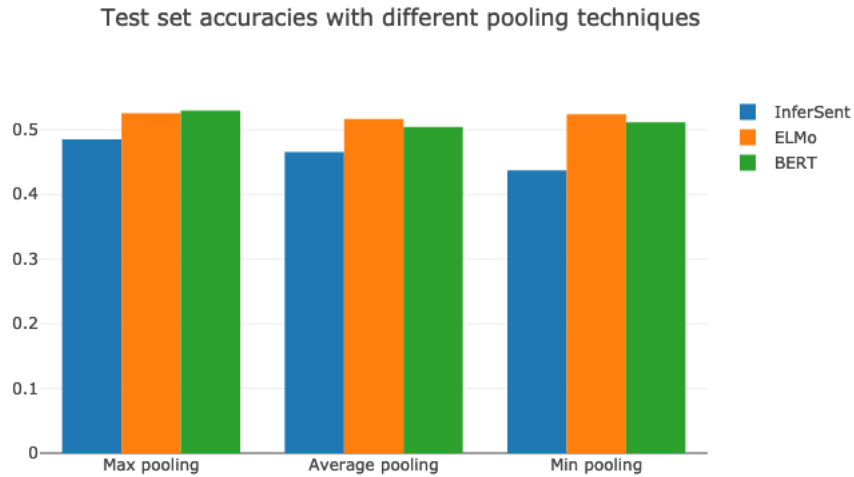


Figure 2: Comparing different pooling strategies.

### 225 4.2 RQ2

226 **At what padding sequence length do neural networks hold the highest**  
227 **accuracy when classifying fake news?**

228 The answer to this question will be given by comparing accuracy of a bidirectional  
229 LSTM architecture with variable padding lengths.

230 By comparing all embedding techniques, I plan on getting a peak padding  
231 length with the best overall performance shared by all embedding methods. At  
232 this moment, the optimal length averages at around a length of 22.

Test set accuracy of padded datasets with variable maximum lengths

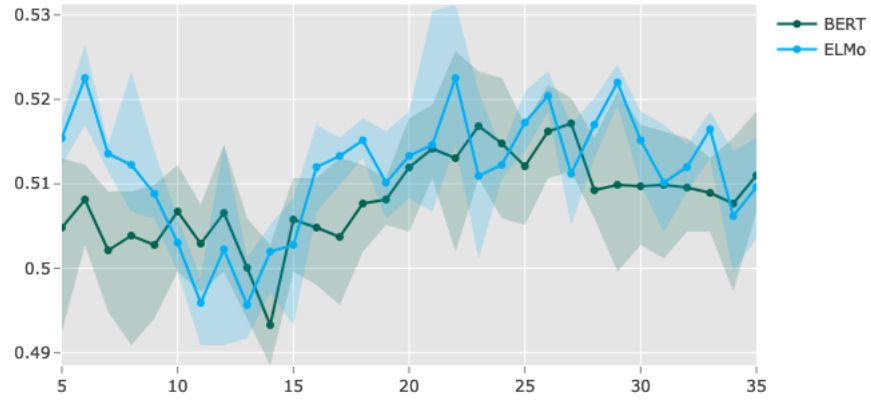


Figure 3: Comparing different maximum padding lengths.

### 4.3 RQ3

**How well do neural network classification architectures classify fake news compared to non-neural classification algorithms?**

The answer of this question will be given by comparing two linear classifiers with two neural classifiers.

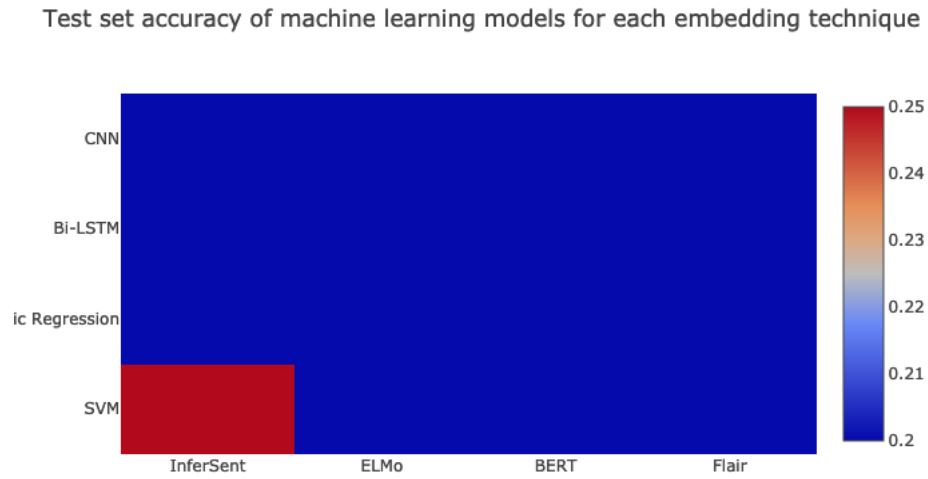


Figure 4: Comparing linear classifiers with neural classifiers.

## 238 5 Conclusions

### 239 5.1 Acknowledgements

## References

- [1] About fakerfact.
- [2] Sequence preprocessing.
- [3] Mevan Babakar and Will Moy. The state of automated factchecking. Technical report, Full Fact, 2016.
- [4] Y-Lan Boureau, Jean Ponce, and Yann LeCun. A theoretical analysis of feature pooling in visual recognition. In *Proceedings of the 27th international conference on machine learning (ICML-10)*, pages 111–118, 2010.
- [5] European Commission. Fake news and online disinformation. <https://ec.europa.eu/digital-single-market/en/fake-news-disinformation>, 2018. Retrieved on 8th of April, 2019.
- [6] Jacob Devlin, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. Bert: Pre-training of deep bidirectional transformers for language understanding. *arXiv preprint arXiv:1810.04805*, 2018.
- [7] Lee Howell et al. Digital wildfires in a hyperconnected world. *WEF Report*, 3:15–94, 2013.
- [8] Baotian Hu, Zhengdong Lu, Hang Li, and Qingcai Chen. Convolutional neural network architectures for matching natural language sentences. In *Advances in neural information processing systems*, pages 2042–2050, 2014.
- [9] Urja Khurana. The linguistic features of fake news headlines and statements, 2017.
- [10] Yoon Kim. Convolutional neural networks for sentence classification. *arXiv preprint arXiv:1408.5882*, 2014.
- [11] Lev Konstantinovskiy. Sentence embeddings for automated factchecking - lev konstantinovskiy.
- [12] Siwei Lai, Liheng Xu, Kang Liu, and Jun Zhao. Recurrent convolutional neural networks for text classification. In *Twenty-ninth AAAI conference on artificial intelligence*, 2015.
- [13] Amy Mitchell and Hannah Klein. Americans still prefer watching to reading the news – and mostly still through television. 2018.
- [14] Christopher Olah. <https://colah.github.io/posts/2015-08-understanding-lstms/>, August 2015.
- [15] Alec Radford, Jeff Wu, Rewon Child, David Luan, Dario Amodei, and Ilya Sutskever. Language models are unsupervised multitask learners. 2019.
- [16] Dominik Scherer, Andreas Müller, and Sven Behnke. Evaluation of pooling operations in convolutional architectures for object recognition. In *International conference on artificial neural networks*, pages 92–101. Springer, 2010.

- 279 [17] Chengcheng Shao, Giovanni Luca Ciampaglia, Alessandro Flammini, and  
280 Filippo Menczer. Hoaxy: A platform for tracking online misinformation.  
281 In *Proceedings of the 25th International Conference Companion on World*  
282 *Wide Web*, WWW '16 Companion, pages 745–750, Republic and Canton  
283 of Geneva, Switzerland, 2016. International World Wide Web Conferences  
284 Steering Committee.
- 285 [18] Dinghan Shen, Guoyin Wang, Wenlin Wang, Martin Renqiang Min,  
286 Qinliang Su, Yizhe Zhang, Chunyuan Li, Ricardo Henao, and Lawrence  
287 Carin. Baseline needs more love: On simple word-embedding-based models  
288 and associated pooling mechanisms. *CoRR*, abs/1805.09843, 2018.
- 289 [19] Kai Shu, Amy Sliva, Suhang Wang, Jiliang Tang, and Huan Liu. Fake  
290 news detection on social media: A data mining perspective. *CoRR*,  
291 abs/1708.01967, 2017.
- 292 [20] Patrice Y Simard, David Steinkraus, John C Platt, et al. Best practices  
293 for convolutional neural networks applied to visual document analysis. In  
294 *Icdar*, volume 3, 2003.
- 295 [21] William Yang Wang. "liar, liar pants on fire": A new benchmark dataset  
296 for fake news detection. *CoRR*, abs/1705.00648, 2017.
- 297 [22] L. Wen, X. Li, L. Gao, and Y. Zhang. A new convolutional neural network-  
298 based data-driven fault diagnosis method. *IEEE Transactions on Industrial*  
299 *Electronics*, 65(7):5990–5998, July 2018.
- 300 [23] Xiang Zhang, Junbo Zhao, and Yann LeCun. Character-level convolutional  
301 networks for text classification. In *Advances in neural information*  
302 *processing systems*, pages 649–657, 2015.