Uncover Fake News with Machine Learning

A Comparison of Algorithms and Feature Extraction Techniques

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*Abstract*—The author presents a survey of different feature extraction techniques, configurations and machine learning algorithms to predict whether a news article is fake or genuine. The problem is approached solely from a natural language processing perspective and only based on the content of the articles. In an implementation the algorithms and techniques are implemented and compared based on their classification accuracy. Through the explorative design the project forms a foundation for further studies in fake news detection.

Keywords—fake news; text classification; feature extraction; machine learning; comparison

# Introduction

On October 30, 1938 Orson Welles aired his play “The War of the Worlds” about an alien invasion on the US east coast. As most of the audience joined later into the program, the reports about a mass panic caused fear. The reports—when explained later—turned out to be fake. Today, they are a very popular and early example of “fake news”.

Fake news are news articles that are “intentionally and verifiably false and could mislead readers” [1]. In the last years, especially in the 2016 US presidential election, coverage on fake news has alerted major media outlets and politicians. It is believed that fake news spread by social bots and populistic political websites and have influenced the election of Donald Trump as US president.

While in earlier times misinformation in media was mostly accidental or for entertainment purposes, people with malicious agendas have discovered online journalism as an easy and cheap way to spread their agendas. A challenging task for political leaders, journalists and social networks is to detect fake news and to stop their spreading.

Regarded from a machine learning perspective, fake news detection is a binary text classification problem. The distinction can be on basis of metadata (e.g. source of the article) or the text itself. In this report, the author compares different algorithms to text extract features and machine learning algorithms. The expected result is a trained model that classifies news articles based solely on the text into genuine or fake news.

# Related Work

With an increasing number of articles considered as fake news, researchers and the public likewise are searching for reliable ways to debunk hoaxes.

It should be noted in the first place, fake news itself is a broad term and requires a specific definition that is accepted by the research community. This requires particular attention due to the political sensitivity of the topic. In [1] and [2], the authors distinguish fake from genuine news and show sources and audiences of fake news. These articles act as a catalyst to understand fake news.

A number of reports present tools and methods to detect fake news with network analyses, thus considering only metadata for the classification task e.g. networks, conflicting viewpoints or relationships of “likes” and “comments” [3–5].

As mentioned before, this report focuses on detecting fake news only based the content text of the news itself. Text classification is in general a well-researched topic. [4, 6] for example have both researched how to detect fake news with natural language processing approaches for text classification. However, their results show room for improvement. For a general introduction to text classification and natural language processing, compare [7].

Like [6], this report will use the fake news dataset curated in [8] and a sample of genuine articles from [9]. Other sources of fake news articles have also been considered like [10]—but ultimately discarded as they are impure with satiric articles. The implementations are based on the sklearn library for Python [11] that also provides some guidance for text classification. Directives for experiment setup and interpretation stems also from [12, 13].

# Method and Design

In this section, the author explains the sequence of actions that lead from data fetching over feature generation to the conduction of the experiment. All necessary steps are laid out here with their requirements, results and justifications to support the external and internal validity of the project. The experiment procedure shall be reproducible from the description and the attached source code.

## Goal and Challenge

The purpose of the experiment shall be to compare different machine learning algorithms—preferably from different categories—and feature extraction methods for the task of supervised binary text classification. The result of the experiment shall be a ranking of the best combinations. Particularly challenging is in this context the preparation and feature extraction from text.

## Preprocessing

As mentioned before, two datasets from two different sources were used in the project. Both are publicly available. To reduce the risk of a biased fake news dataset, the articles were obtained from the open data platform Kaggle [8]. The 13,000 news pieces covering different topics include text and metadata from over 240 websites and were reviewed by the Kaggle community. The Signal Media news dataset [9] consists of one million news articles and blog entries that were scraped in September 2015. Of these entries, 52,000 articles were selected in a uniform sample. These articles were considered genuine and not fake or biased in any way.

Before assigning binary labels to all articles (1: fake, 0: genuine), all texts were lowercased and stripped from non-word characters, leaving space separated words in each entry. The proportion of fake news in the experiment dataset is similar to the empirical evidence given in [1] in an attempt to reflect a real-world scenario. The selection was shuffled randomly and split into three datasets for the experiment.

1. 13,000 entries/20%: Validation set for development and hyperparameter optimization
2. 39,000 entries/60%: Training set for final performance training
3. 13,000 entries/60%: Test set for final performance evaluation

After this preprocessing step, the entries in the dataset consisted of the text of the article and the binary label for fake or genuine, respectively.

## Feature Generation

In the process of feature generation, multiple algorithms were considered. These included for example *word2vec*, *glove* or other models. However, these were discarded because of the extra effort that would have been necessary to use these opposing to their original intent that is in word classification in sentence or even document classification instead. Since only the text of the articles is available for the classification, algorithms that are based on the metadata were rejected in the first place. The particular challenging task in text analysis is that the text as a sequence of words or symbols cannot be used as input in the machine learning algorithms directly. Because text document vary in length and—at least with no other preparation—consist of characters, a way to represent documents as vectors of fixed length and numerical values has to be found.

After the prior elimination steps and the new criteria, the bag-of-words model (also known as vector space model or bag of n-grams) seemed most promising.

In this model, the sentences or texts are split on whitespaces or punctuation as separators and represented as a multiset of its words. This removes some information about the structure of the text, the grammar and word order, but keeps the multiplicity of each word in the text. The idea is to use the number of occurrences as a feature in training the classifier. The algorithm shall be explained in a little example to familiarize with the conceptuality.

Considering two documents: *“Adam enjoys to go out. Eve enjoys to go out too.”*, *“Adam also enjoys to go swimming”* and splitting after each whitespace and punctuation, leads to the following multiset of words: *[“Adam”, “enjoys”, “to”, “go”, “out”, “Eve”, “too”, “also”, swimming”]*. This is named *“vocabulary"*. These are all words that known to the algorithm. While this bag of words offers multiple ways to characterize the text, the most common and useful in this setting is to calculate the number of times one of the terms from the vocabulary appears in the input text. Doing this will result in an *n* long vector for each input text, where *n* is the length of the vocabulary and each entry is the number of times the term in position *i* of the vocabulary appeared in the text. In the example, the following two vectors would result in this two vectors:

1. [1, 2, 2, 2, 2, 1, 1, 0, 0]
2. [1, 1, 1, 1, 0, 0, 0, 1, 1]

Note that as mentioned before this representation removes the information of sentence structure. A problem with this representation however, is that it overvalues very common words in languages like “to”, “a” or “the” in the English language. These so called stop-words will (in longer texts than in the example) most often have the highest term frequency and thus be noise in the input for the machine learning algorithms, as they do not provide additional information. To remove this noise, a list of these stop words can be used. These words will then be skipped when the vocabulary is generated.

The bag of words model offers some more variation that could yield better results. This introduces for example the idea of *n-gram* models. These can be used to store some information about the context of word occurrences in text. The bag of words is a special case of the n-gram model where *n=1*. Consequently, a bigram (n=2) model vocabulary splits the text into units of two words, e.g. “John likes”, “likes to” … in the vocabulary and calculates the term frequency as mentioned above. Here as well, lists of stop words can be used to reduce noise. In the project, n-gram models were used where n was between 1 and 3. Additionally, a number of minimum occurrences was set for each model. If a word or combination of words occurred less times in the whole corpus than this threshold, it was not considered as a feature in the vector. Again, this may result in loss of information. However, if the combination did not occur enough times, it would have small influence on the training anyway and not provide additional information. Furthermore, smaller vectors obviously improve training and test speed.

Another approach to emphasize terms that may be rare but interesting and that are shadowed by very frequent terms that have not been identified as stop words, is to use the inverse document-frequency.

The tf-idf term weighting re-weights the count features into floating point values. A high value is given by a high term frequency in a particular text (tf) and a low frequency of the term in the entire corpus (idf). The value is calculated as follows:

1. tf-idf(t,d) = tf(t,d) ∙ idf(t), where
2. idf(t) =

In these equations, *nd* stands for the total number of documents and *df(d, t)* is the number of documents that contain the term. The resulting vectors are then normalized so all values are between *0* and *1*. As this transformation is an extra step after vectorising, it was conducted in the project for the described ngram vectors.

A more practical problem when vectorising a large corpus with bag of words is that the mapping from the terms to integer features happens in-memory. For larger datasets, the vocabulary is obviously large too and thus, the memory requirements may exceed the machine limits. Furthermore, when fitting, even more intermediate data structures have to be used. As a global vocabulary must be maintained in vectorising, parallelisation requires so much overhead that it is not implemented in the standard library, because it would make the algorithm in effect slower.

The biggest consummator of memory is undoubtedly the dictionary that holds the mapping of vocabulary to vector indices. To phase out this problem, [14] proposed to use hash functions to map terms directly to indices. Thus, no memory is required at all to store the dictionary. By providing a sufficiently large amount of hash buckets or increasing their number in the progress, hash collisions can be avoided. While hashing makes parallelization, it does not have a bad effect on model performance, as shown in [15].

## Choice of Algorithms

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## Hyperparameter Optimization

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## Experiment

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# Results and Analysis

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# Conclusions

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# Future Work

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