

Fake News Detection with Generated Comments for News Articles

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Abstract—Recently, fake news is shared via social networks and makes wrong rumors more diffusible. This problem is serious because the wrong rumor sometimes make social damage by deceived people. Fact-checking is a solution to measure the credibility of news articles. However the process usually takes a long time and it is hard to make it before their diffusion. Automatic detection of fake news is a popular researching topic. It is confirmed that considering not only articles but also social contexts(i.e. likes, retweets, replies, comments) supports to spot fake news correctly. However, the social contexts are naturally unavailable when an article comes out, making early fake news detection by means of the social context useless. We propose a fake news detector with the ability to generate fake social contexts, aiming to detect fake news in the early stage of its diffusion where few social contexts are available. The fake context generation is based on a fake news generator model. This model is trained to generate comments using a dataset which consists of news articles and their social contexts. In addition, we also trained a classify model. This used news articles, real-posted comments, and generated comments. To measure our detector's effectiveness, we examined the performance of the generated comments for articles with real comments and generated ones by the classifying model. As a result, we conclude that considering a generated comment help detect more fake news than considering real comments only. It suggests that our proposed detector will be effective to spot fake news on social networks.

Index Terms—fake news, disinformation, neural network, natural language processing, deep-learning, microblogs

I. INTRODUCTION

In this era, social media is one of the important parts of our lives. Social media makes it easier to get news and share them with friends online. However, there is also information with less credibility. Some of them have misinformation that is made by malicious purposes. We call them “fake news”.

Fake news tries to make false rumors diffusible by being shared. This year, there is so much fake news on COVID-19 and sometimes make wrong rumors in the social networks. Director-General of the WHO called this problem “infodemic” and he told that fake news is shared faster and more easily

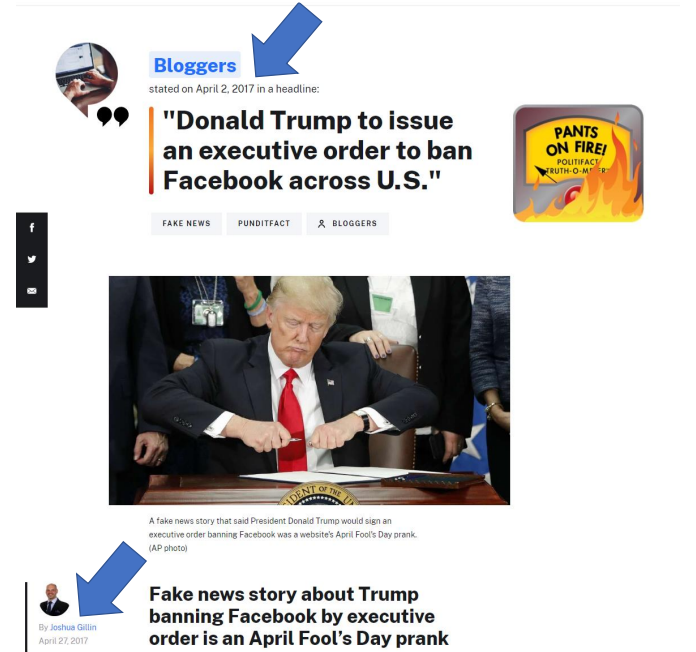


Fig. 1. An example of fact-checking. It is confirmed as an April Fool's prank. The blue arrows show the posted date of the fake news and the fact-checking result. It takes 25 days for the news to be verified as *fake*.

than the virus itself [1]. Besides, fake news created some not only online, but also offline (real incidents) e.g. in Washington D.C., fake news on the Pizzagate conspiracy is reported to have motivated the shooting [2]. Nowadays, fact-checking is the most used method to spot fake news. This is a process of evaluating news by people who have knowledge of news topic. Fig. 1 is an example of fact-checking [3]. However, this takes so long that it is hard to spot a piece of fake news before it is shared. Fake news also shakes the premise of democracy due to people cannot get accurate information. Therefore, researches

try to detect fake news through machine learning.

The challenge of this work is there are news articles which try to deceive readers on purpose and this makes it harder to classify them by a simple rule-based method. Trying to supplement information for detection, there are some works which aggregate social context(i.e. retweet, like, and comments) report better results than considering news text only [4]. However, social contexts are unavailable before being shared. Hence, there is also a work that generates words likely to be appeared in comments from the news by Conditional Variational AutoEncoder (CVAE) to detect fake news when they are just posted [5]. This model uses hidden variables from article with probability distribution and labels. Although their work tries to generate comments, they have only achieved to produce words that have a high probability of appearing in the comments.

In this work, we will propose a generation model that evaluates news credibility by news text and generated comments. This model is modified from generating fake news articles [6] and this model learns not only news features but also how to generate comments. In training, this sequence includes real posted comments but the test sequence does not use them. The skill of generating comments help classification in the test data.

We measure the performance of our proposed method by experiments with a real posted dataset.

II. RELATED WORKS

To detect and classify fake news is not a new topic because it is similar to detecting spam [7], rumor [8], and false advertisement [9]. Following previous works [10]–[12], we define fake news as news that is intentionally fabricated and can be verified as wrong.

A. Detecting fake news

There are many works which detect fake news based on the news content only. In-text features, writing styles [13] and amount of emotions [14] were considered as promising features because commonly fake news has unique styles and emotions. Besides, using deep neural networks achieved better results in classification on previous works [15]–[17].

Many works consider the social context of news content. The social context features are generated by user-based [18]–[20], post-based [21]–[23], and network-based [24], [25].

Considering the social context, the detection must wait for a while from posting of an article because social contexts are made by users who are exposed to the article. Therefore, the Two-Level Convolutional Neural Network with User Response Generator(TCNN-URG) was proposed [5]. This generates comment by hidden variables which are trained by a probability distribution of comments appearance. Generated comments can give additional information to classify posts and the model is available even if the news is just posted. However, the TCNN-URG generates only words that have a high probability of appearing in a comment and it generates no grammatical elements.

B. Generating fake news

In generating natural language articles, the Grover model made natural neural fake news articles [6]. This model is trained by a news dataset where news articles are organized in fields such as news domain, author, posted date, title, and article. The model was evaluated by the performance of the prediction of one of the news elements. An interesting finding made by them is that human beings are more likely to be fooled by generated articles than by real ones. We tried to extend this model and generate natural comments.

III. METHODOLOGY

According to a previous work [26], a text generation model is a language modeling problem. The work defined a document $x = w_1^T = (w_1, w_2, \dots, w_T)$ as the product of the conditional probabilities to generate word w_t by previous words w_1^{t-1} like below:

$$p(x) = p(w_1^T) = \prod_{t=1}^T p(w_t | w_1^{t-1}) \quad (1)$$

A text generation diagram with the model is shown in Fig. 2. As we saw in II-B, the original Grover model was trained by a news dataset which had five parts. Each part is attached to the start and end tokens in order to facilitate efficient learning and generation [6]. After the training, data without the tags are given to evaluate prediction performance. We replaced the fields other than the article with three comments and tried to predict one of the comments from the other fields. We defined a field set consists of an article and three comments as an instance. We modeled the text generation by the joint distribution like the original one:

$$p(\text{article}, \text{comment}_1, \text{comment}_2, \text{comment}_3) \quad (2)$$

Following Grover’s method, we randomly partitioned the document fields into two sets. We also randomly dropped out individual fields with probability 10% to train the model, and dropped out all but the article body with probability 35% [6]. The generation model is trained to minimize the cross-entropy in prediction in one field set followed by the tokens in another set. Basically our model is constructed by replacing fields in Grover model’s news structure with comments, except for article. The purpose of our model is to generate not articles but comments likely to be written by SNS users.

The last token of news fields which are integrated with begin/end token is [CLS] and this is used for classification into real/fake. This is the same method as for GPT-2 [27]. Although the original one was designed for the generation of fake news, our proposed model was arranged to generate comments. Fig.3 shows the process of our experiment. First of all, we sampled dataset’s instances and we trained a model to generate comments. In the classification, we removed a comment from each instance and replaced it with a generated comment by inference of the trained comment generator from the other fields(a document and two comments). The classifier



Fig. 2. Two cases of comment generation with our proposed model. (a) shows a case where a comment was generated from an article and a real-posted comment. (b) shows another case where a comment was generated from data that includes the generated comment in (a).

learned these instances and we compared results with instances which did not have generated comments.

IV. RESULTS

A. Word generation tendency

First of all, we investigated the difference between generated comments from real and fake news. We generated comments which refer to news articles that are fact-checked by PolitiFact from the FakeNewsNet dataset [28]. This dataset contains sets of a news article and tweets (comments) which refer to it. We chose news articles which have at least three tweets and sampled three tweets for comment generation. We prepared 200 sets of news articles and comments for each of the real and fake classes and trained the model to generate comments. We used the following indexes to evaluate words appeared in the generated comments: the number of the occurrence of the words (shown in percentage), ratio of the word's occurrence among the total number of words, and the difference between the percentages for real and fake classes. We converted all alphabets to the lowercase letter. We removed the following elements: stop words provided by NLTK [29], url (starts with *http*), and symbols such as quotation, period, comma, and so on in order to investigate the frequency of not symbols but words accurately. On the other hand, we spared mentions, colons, and hashtags (i.e. @anyone, analyze:, #anything) because the addition of these symbols serves different purposes in the social networks. We found the following by the analysis of the generated comments:

- The most frequent word was “via” (approx. 1.5%) in the aggregated frequency in real and fake.
- The second and third were “trump” and “obama” however both of their percentages were under 1%.

We also found the following from the difference between generated comments from real and fake news.

- The word “via” was also the top frequency of generated word from both real and fake.
- The percent of the frequency of “via” in generated comments from fake news article was twice as much as ones from real news.
- The word “via” was also the word with the largest margin of the percentages between real and fake classes. The margin was approx. 0.9 point.
- The word “breaking:” was the word with the second-largest margin of the percentages between real and fake classes, where one for the fake was more than the real. The margin was approx. 0.7 point.

B. Quality of classification

We measured the effect of generated comments for classification by comparing classification results with and without the generated comments. We prepared baselines: classification with the news article only, and with the article and two real-posted comments. In this experiment, we used pairs of an article of GossipCop, another data available in the FakeNewsNet dataset, and tweets referring it instead of PolitiFact because the latter has too few data to make the experiment meaningful. We sampled the same rule as IV-A although we collect 2000 sets each for the real and fake classes. The result of classification is Table I. Our proposed method achieved the best recall score however in precision it was outperformed by models that disregard the generated comments. On the whole, the generated comments seemed to be not accurate in grammar.

V. DISCUSSION

A. Generating comments

According to trends of words in generated comments, our proposed method seemed to be trained by the topics of news articles. Most of the generated comments referred to topics of politics and this may be caused by the character of the dataset.

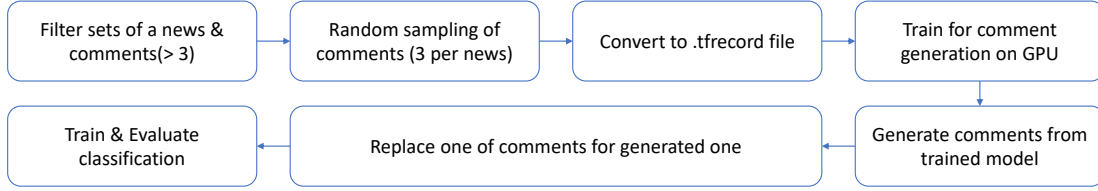


Fig. 3. The process of our experiment.

TABLE I
RESULTS OF CLASSIFICATION

| Model name | Precision | Recall | F1 score |
|---------------------|--------------|--------------|--------------|
| Article only | 0.647 | 0.615 | 0.631 |
| + Real comment * 2 | 0.682 | 0.750 | 0.714 |
| + Generated comment | 0.590 | 0.790 | 0.675 |

An interesting word in the generated comments is “breaking:”. Our experimental results showed that the word was generated more by fake news than real news. The phenomenon was not reported in the research of TCNN-URG [5]. Their research claimed that “!”, “?”, “false”, and so on were important signals of fake news. The word “breaking:” maybe also a signal of fake news.

The grammatical quality of the generated comments was clearly poor. This is caused by a lack of dataset scale. Grover model was built using 120 gigabytes of dataset [6]. We need to search or get a larger dataset of articles and tweets.

B. classification

According to TABLE I, our proposed model achieved the best recall score however in precision its performance was worst. This means the proposed model can detect more fake news than another model which disregards generated comments even if available social contexts are limited.

The trend suggests that this model helps people who search for news which require fact-checking. However, the model also detected more false fake news than another one therefore we need to make an improvement. We will check if the trend is changed by using a larger dataset.

VI. CONCLUSION

This article tried to solve problems in the early detection of fake news. We focused on the fact that although user’s comments might provide important information to evaluate news documents there are few comments in an early stage of news propagation. Therefore, we made a neural network model that was extended from the Grover model to generate comments to help classification. We experimented to evaluate our proposed model’s performance in early detection with generating a comments. The results suggested that the process

of generating comments may help the classifiers in fact-checking to decide real or fake.

APPENDIX SETTINGS OF EXPERIMENTS

- Trained on Ubuntu 16.04 on Docker in Linux server with TITAN X (Pascal).
- Our proposed model was extended from Grover repository by forking on GitHub.
- Model size was Grover-Base but we reduced vocabulary a little bit in order to fit for the extension.

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REFERENCES

- [1] J. Zarocostas, “How to fight an infodemic,” *The Lancet*, vol. 395, no. 10225, p. 676, 2020. [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S014067362030461X>
- [2] G. staff and agencies, “Washington gunman motivated by fake news ‘pizzagate’ conspiracy,” 12 2016. [Online]. Available: <https://www.theguardian.com/us-news/2016/dec/05/gunman-detained-at-comet-pizza-restaurant-was-self-investigating-fake-news-reports>
- [3] J. Gillin, “Politifact - fake news story about trump banning facebook by executive order is an april fool’s day prank,” Apr 2017. [Online]. Available: <https://www.politifact.com/factchecks/2017/apr/27/blog-posting/fake-news-story-about-trump-banning-facebook-execu/>
- [4] H. Guo, J. Cao, Y. Zhang, J. Guo, and J. Li, “Rumor detection with hierarchical social attention network,” in *Proceedings of the 27th ACM International Conference on Information and Knowledge Management*, ser. CIKM ’18. New York, NY, USA: ACM, 2018, pp. 943–951. [Online]. Available: <http://doi.acm.org/10.1145/3269206.3271709>
- [5] F. Qian, C. Gong, K. Sharma, and Y. Liu, “Neural user response generator: Fake news detection with collective user intelligence,” in *Proceedings of the Twenty-Seventh International Joint Conference on Artificial Intelligence, IJCAI-18*. International Joint Conferences on Artificial Intelligence Organization, 7 2018, pp. 3834–3840. [Online]. Available: <https://doi.org/10.24963/ijcai.2018/533>
- [6] R. Zellers, A. Holtzman, H. Rashkin, Y. Bisk, A. Farhadi, F. Roesner, and Y. Choi, “Defending against neural fake news,” in *Advances in Neural Information Processing Systems 32*, H. Wallach, H. Larochelle, A. Beygelzimer, F. d’Alché-Buc, E. Fox, and R. Garnett, Eds. Curran Associates, Inc., 2019, pp. 9054–9065. [Online]. Available: <http://papers.nips.cc/paper/9106-defending-against-neural-fake-news.pdf>
- [7] H. Shen, F. Ma, X. Zhang, L. Zong, X. Liu, and W. Liang, “Discovering social spammers from multiple views,” *Neurocomputing*, vol. 225, pp. 49–57, 2017.

- [8] Z. Jin, J. Cao, Y. Jiang, and Y. Zhang, "News credibility evaluation on microblog with a hierarchical propagation model," in *2014 IEEE International Conference on Data Mining*, 12 2014, pp. 230–239.
- [9] H.-H. Huang, Y.-W. Wen, and H.-H. Chen, "Detection of false online advertisements with dcnn," in *Proceedings of the 26th International Conference on World Wide Web Companion*, ser. WWW '17 Companion. Republic and Canton of Geneva, Switzerland: International World Wide Web Conferences Steering Committee, 2017, pp. 795–796. [Online]. Available: <https://doi.org/10.1145/3041021.3054233>
- [10] K. Shu, A. Sliva, S. Wang, J. Tang, and H. Liu, "Fake news detection on social media: A data mining perspective," *SIGKDD Explor. Newsl.*, vol. 19, no. 1, pp. 22–36, Sep. 2017. [Online]. Available: <http://doi.acm.org/10.1145/3137597.3137600>
- [11] N. Ruchansky, S. Seo, and Y. Liu, "Csi: A hybrid deep model for fake news detection," in *Proceedings of the 2017 ACM on Conference on Information and Knowledge Management*, ser. CIKM '17. New York, NY, USA: ACM, 2017, pp. 797–806. [Online]. Available: <http://doi.acm.org/10.1145/3132847.3132877>
- [12] Y. Wang, F. Ma, Z. Jin, Y. Yuan, G. Xun, K. Jha, L. Su, and J. Gao, "Eann: Event adversarial neural networks for multi-modal fake news detection," in *Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, ser. KDD '18. New York, NY, USA: ACM, 2018, pp. 849–857. [Online]. Available: <http://doi.acm.org/10.1145/3219819.3219903>
- [13] M. Potthast, J. Kiesel, K. Reinartz, J. Bevendorff, and B. Stein, "A stylometric inquiry into hyperpartisan and fake news," *CoRR*, vol. abs/1702.05638, 2017. [Online]. Available: <http://arxiv.org/abs/1702.05638>
- [14] C. Guo, J. Cao, X. Zhang, K. Shu, and M. Yu, "Exploiting emotions for fake news detection on social media," *CoRR*, vol. abs/1903.01728, 2019. [Online]. Available: <http://arxiv.org/abs/1903.01728>
- [15] W. Y. Wang, "liar, liar pants on fire": A new benchmark dataset for fake news detection," in *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*. Vancouver, Canada: Association for Computational Linguistics, Jul. 2017, pp. 422–426. [Online]. Available: <https://www.aclweb.org/anthology/P17-2067>
- [16] H. Karimi and J. Tang, "Learning hierarchical discourse-level structure for fake news detection," in *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*. Minneapolis, Minnesota: Association for Computational Linguistics, Jun. 2019, pp. 3432–3442. [Online]. Available: <https://www.aclweb.org/anthology/N19-1347>
- [17] H. Karimi, P. Roy, S. Saba-Sadiya, and J. Tang, "Multi-source multi-
- [24] L. Wu and H. Liu, "Tracing fake-news footprints: Characterizing social media messages by how they propagate," in *Proceedings of the Eleventh ACM International Conference on Web Search and Data Mining*, ser. class fake news detection," in *Proceedings of the 27th International Conference on Computational Linguistics*. Santa Fe, New Mexico, USA: Association for Computational Linguistics, Aug. 2018, pp. 1546–1557. [Online]. Available: <https://www.aclweb.org/anthology/C18-1131>
- [18] C. Castillo, M. Mendoza, and B. Poblete, "Information credibility on twitter," in *Proceedings of the 20th International Conference on World Wide Web*, ser. WWW '11. New York, NY, USA: ACM, 2011, pp. 675–684. [Online]. Available: <http://doi.acm.org/10.1145/1963405.1963500>
- [19] K. Shu, S. Wang, and H. Liu, "Understanding user profiles on social media for fake news detection," in *2018 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR)*, 4 2018, pp. 430–435.
- [20] K. Shu, X. Zhou, S. Wang, R. Zafarani, and H. Liu, "The role of user profile for fake news detection," *CoRR*, vol. abs/1904.13355, 2019. [Online]. Available: <http://arxiv.org/abs/1904.13355>
- [21] S. Yang, K. Shu, S. Wang, R. Gu, F. Wu, and H. Liu, "Unsupervised fake news detection on social media: A generative approach," in *AAAI*, 2019.
- [22] E. Tacchini, G. Ballarin, M. L. D. Vedova, S. Moret, and L. de Alfaro, "Some like it hoax: Automated fake news detection in social networks," *ArXiv*, vol. abs/1704.07506, 2017.
- [23] Z. Jin, J. Cao, Y. Zhang, and J. Luo, "News verification by exploiting conflicting social viewpoints in microblogs," in *Proceedings of the Thirtieth AAAI Conference on Artificial Intelligence*, ser. AAAI'16. AAAI Press, 2016, pp. 2972–2978. [Online]. Available: <http://dl.acm.org/citation.cfm?id=3016100.3016318>
- [24] WSDM '18. New York, NY, USA: ACM, 2018, pp. 637–645. [Online]. Available: <http://doi.acm.org/10.1145/3159652.3159677>
- [25] F. Monti, F. Frasca, D. Eynard, D. Mannion, and M. M. Bronstein, "Fake news detection on social media using geometric deep learning," *CoRR*, vol. abs/1902.06673, 2019. [Online]. Available: <http://arxiv.org/abs/1902.06673>
- [26] Y. Bengio, R. Ducharme, P. Vincent, and C. Janvin, "A neural probabilistic language model," *J. Mach. Learn. Res.*, vol. 3, no. null, p. 1137–1155, Mar. 2003.
- [27] A. Radford, J. Wu, R. Child, D. Luan, D. Amodei, and I. Sutskever, "Language models are unsupervised multitask learners," 2018. [Online]. Available: <https://d4mucfpksywv.cloudfront.net/better-language-models/language-models.pdf>
- [28] K. Shu, D. Mahudeswaran, S. Wang, D. Lee, and H. Liu, "Fakenewsnet: A data repository with news content, social context and dynamic information for studying fake news on social media," *ArXiv*, vol. abs/1809.01286, 2018.
- [29] S. Bird and E. Loper, "NLTK: The natural language toolkit," in *Proceedings of the ACL Interactive Poster and Demonstration Sessions*. Barcelona, Spain: Association for Computational Linguistics, Jul. 2004, pp. 214–217. [Online]. Available: <https://www.aclweb.org/anthology/P04-3031>