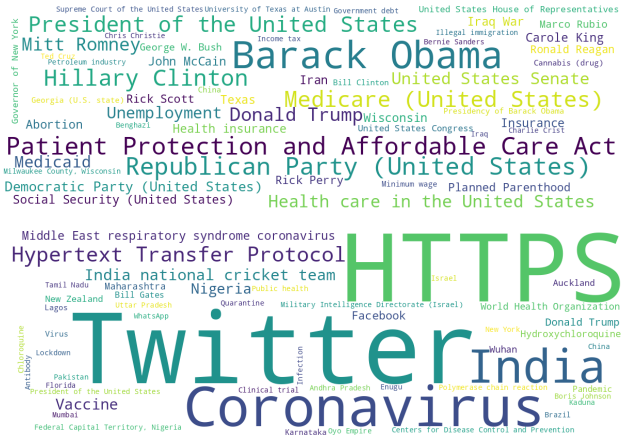

Figure 2: Word clouds for the 50 most frequent entities linked by ERNIE in LIAR (top) and COVID-19 (bottom).

27.31%, below the accuracy of ERNIE (27.53%).

Discussion

The reliable improvement of detection accuracy on LIAR by integrating PLMs with Wikidata shows the potential of knowledge integration exceeding the results obtained by integrating multiple types of metadata by **?**. On the other hand, the improvements are good but not dramatic for LIAR and not consistent for COVID-19. We can identify two aspects contributing to the result which are relevant to the effective use of knowledge-enhanced models:

1) Currentness and relevance of the KB: as COVID-19 was collected after most of the PLMs were trained, some terms such as "COVID-19" are not in the KB;

2) Quality of the dataset: the COVID-19 dataset contains confounders that provide strong cues, overshadowing the impact of the knowledge base. The most important one is the occurrence of https links, which appear in 95.3% of the real posts but only 42.3% of the fake posts.

There is also potential to achieve more explainability and interpretability with direct KB integration at runtime. Take this statement from COVID-19: *"DNA Vaccine: injecting genetic material into the host so that host cells create proteins that are similar to those in the virus against which the host then creates antibodies"* as an example, KnowBert-W+W correctly classifies it as "real", whereas BERT-base fails. We observe most mention spans in the statement, i.e. *"DNA"*, *"injecting"*, *"genetic"*, *"genetic material"*, *"host"*, *"cells"*, etc. are correctly linked to entities *"DNA"*, *"Injection_(medicine)"*, *"Genetics"*, *"Genome"*, *"Host_(biology)"*, *"Cell_(biology)"*, respectively, therefore it seems that the entity links may have contributed to KnowBert-W-W for this classification. However, the level of explainability is still limited.

Application Aspects Automatic fake news detection in practice adds two dynamic application aspects, which are difficult to test with static datasets as our experiment on COVID-19 has shown:

(1) Dynamic adaptation: it is necessary to update the system to the changing characteristics of real and fake news (**?**). Knowledge-enhanced models that use KBs at runtime offer an opportunity to update the KB independent of the model. This has the advantage that fake news can be recognised as contradicting the KB before there are any fake news examples.

(2) Adversarial robustness: fake news authors are very likely to take evasive action. Adapting the text style is relatively easy and could be automated, which makes the detection with stylistic features difficult (see **??**).

Deployment of fake news detection in social media will also need human verification, e.g. when a user challenges actions taken against them. Here, KB integration can offer the advantage of insight into knowledge that has been used in the detection for better explainability.

Related Work

In recent years large-scale PLMs i.e. BERT and RoBERTa have dominated NLP tasks, including some content-based fake news detection (**?**). Most fake news detection approaches either combine text with metadata (e.g. **?**) or focus only on the source of the text (e.g. **?**). For LIAR, **?** extend the data with evidence sentences in a new dataset called LIAR-PLUS to improve detection. **?** introduce a Deep Averaging Network to model the discursive structure of the text and use Siamese models on the extended text data. **?** predict labels at two levels of granularity. For COVID-19, there are a number of results from the CONSTRAINTS 2021 workshop (**?**) which use a wide variety of traditional and neural NLP models. None of these approaches uses external knowledge, so they could all benefit from KB integration.

Conclusion and Future Work

In this paper, we study the effectiveness of enhancing PLMs with knowledge bases for fake news detection. We find that integrating knowledge with PLMs can be beneficial on a static dataset but it depends on suitable KBs and the quality of the data. On the modelling level, there are many routes for improvement. For practical application, more insight into what knowledge is used would be useful as well as dynamic adaptation of the models and the KBs. Integrating KBs with PLMs offers potentially more robust and timely fake news detection. However, a new evaluation approach, i.e. a testing scenario that models dynamic knowledge as well as adversarial and automatic fake news generators, is needed to assess the true potential of knowledge integration.

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