Evaluation Discrepancy Discovery: A Sentence Compression Case-study

Yevgeniy Puzikov∗
Ubiquitous Knowledge Processing Lab (UKP Lab),
Department of Computer Science, Technical University of Darmstadt

https://www.ukp.tu-darmstadt.de

Abstract

Reliable evaluation protocols are of utmost importance for reproducible NLP research. In this work, we show that sometimes neither metric nor conventional human evaluation is sufficient to draw conclusions about system performance. Using sentence compression as an example task, we demonstrate how a system can game a well-established dataset to achieve state-of-the-art results. In contrast with the results reported in previous work that showed correlation between human judgements and metric scores, our manual analysis of state-of-the-art system outputs demonstrates that high metric scores may only indicate a better fit to the data, but not better outputs, as perceived by humans. The prediction and error analysis files are publicly released.

1 Introduction

1.1 Task description

Sentence compression is a Natural Language Processing (NLP) task in which a system produces a concise summary of a given sentence, while preserving the grammaticality and the important content of the original input. Both abstractive (Cohn and Lapata, 2008; Rush et al., 2015) and extractive (Filippova and Altun, 2013; Filippova et al., 2015; Wang et al., 2017; Zhao et al., 2018) approaches have been proposed to tackle this problem. Most researchers have focused on the extractive methods, which treat this as a deletion-based task where each compression is a subsequence of tokens from its original sentence (Figure 1).

Dickinson, who competed in triple jump at the 1936 Berlin Games, was also a bronze medalist in both the long jump and triple jump at the 1938 Empire Games.

(a) Input sentence

Dickinson competed in triple jump at the 1936 Berlin Games.

(b) Reference compression

Dickinson was a bronze medalist in the long jump and triple jump at the 1938 Empire Games.

(c) Another possible compression

Figure 1: Sentence compression example from the Google Dataset: an input sentence and a reference compression. The compression candidate at the bottom is also a valid one, but would score low, because the n-gram overlap with the reference is small.

∗Research done during an internship at Bloomberg L.P., London, United Kingdom.

https://github.com/UKPLab/arxiv2021-evaluation-discrepancy-nsc
In the past few years several novel methods have been proposed to tackle the task of sentence compression. Most of these methods have been evaluated using the Google Dataset (Filippova and Altun, 2013) or its derivatives. Most authors present approaches that show better metric scores; a few of them also describe human evaluation experiments and show that the proposed methods outperform previous work. However, there has been a serious lack of analysis done on actual model predictions. In this work we show that metric scores obtained on the Google Dataset might be misleading; a closer look at model predictions reveals a considerable amount of noise, which renders the trained model predictions ungrammatical. Another problem is that valid system outputs which do not match the references are severely penalized. For example, a plausible compression for the introductory example we used above would be Dickinson was a bronze medalist in the long jump and triple jump at the 1938 Empire Games. However, with the established evaluation protocol, this compression would score very low because of the insignificant token overlap with the reference. We showed that evaluating a system on the Google Dataset is tricky, and even human evaluation done in the previous years could not detect the issues described in this chapter.

To summarize, our contributions in this study are:

• We introduce a simple method of sentence compression that established new state-of-the-art results, as measured by common metrics.

• We design an experiment with a contrived system which achieved even higher scores, but produced less grammatical and less informative outputs.

• We show that this discrepancy may be attributed to the noise in the dataset.

2 Data Analysis

In our experiments we use the Google Dataset introduced by Filippova and Altun (2013). This dataset was constructed automatically by collecting English news articles from the Internet, treating the first sentence of each article as an uncompressed sentence and creating its extractive compression using a set of heuristics and the headline of the article. The dataset contains 200 000 training and 10 000 evaluation instances; the first 1 000 data points from the latter are commonly used as a test set and the remaining 9 000 as a development set.

Exploratory data analysis showed that the distribution of the training data is highly skewed, which is not surprising though, given the nature of the data.

In order to remove outliers and fit the computation budget, we removed instances which contained sentences longer than 50 tokens and compressions longer than 17 tokens. We also removed examples with tokens longer than 15 characters, since those in most cases denoted website links. Finally, we excluded cases with a compression ratio of more than 0.85 — those rare cases in most cases were too long to qualify as compressions. Evaluation on the development and test sets was done without any data filtering.

3 BERT-based Sentence Compression

Most modern deletion-based compression systems adopt either a tree-pruning, or a sequence labeling approach. The former uses syntactic information to navigate over a syntactic tree of a sentence and decide which parts of it to remove (Knight and Marcu, 2000; McDonald, 2006; Filippova and Altun, 2013). With the advent of sequence-to-sequence models it became possible to skip the syntactic parsing step and solve the task directly, by processing a sentence one token at a time and making binary decisions as to whether to keep a token or delete it (Filippova et al., 2015; Wang et al., 2017; Zhao et al., 2018; Kamigaito and Okumura, 2020). The advantages of such approaches include a lesser chance of introducing error propagation from incorrect parsing decisions, as well as higher training and inference speed.

For a long time the space of sequence-to-sequence models has been dominated by different variants of Recurrent Neural Networks (RNN) (Rumelhart et al., 1986). However, a more recent Transformer architecture (Vaswani et al., 2017) has shown very promising results in many NLP tasks. Given the success of Bidirectional Encoder Representations from Transformers (BERT) (Devlin et al., 2019), and the
fact that there has been no empirical evaluation of its performance in sentence compression, we decided to fill this gap and find out how well BERT-based models would cope with the task.

We used pretrained BERT-base-uncased model weights[^3] provided by the HuggingFace library (Wolf et al., 2020), and implemented a simple BERTUNI model which encodes the source sentence \( S = \{w_1, w_2, \ldots, w_n\} \) and produces a sequence of vectors \( V = \{v_1, v_2, \ldots, v_n\}, v_i \in \mathbb{R}^h \). Each vector is fed into a dense layer with a logistic function as a non-linear function to produce a score \( s_i \in [0, 1] \) (Figure 3).

If \( s_i \geq 0.5 \), the model output is 1 (and 0, otherwise).

A simple decision rule was used to make a binary prediction:

\[
\text{decision} = \begin{cases} 
1, & \text{if } s \geq 0.5, \\
0, & \text{otherwise}.
\end{cases}
\]

4 Experiments

4.1 Automatic Metric Evaluation

For automatic evaluation of sentence compression systems, most researchers follow Clarke and Lapata (2006) and Filippova and Altun (2013) and use the following two metrics:

- **F1-score**: harmonic mean of the recall and precision in terms of tokens kept in the target and the generated compressions.

[^3]: [https://huggingface.co/bert-base-uncased](https://huggingface.co/bert-base-uncased)
• Compression ratio (CR): the length of the compression divided over the original sentence length.

The former metric shows how close the model outputs are to the references. The latter one is supposed to measure the compression effectiveness.

To make our results comparable to previous work, in our experiments we followed the same convention. However, we would like to note that measuring CR in sentence compression might be redundant for several reasons. The first reason comes from the fact that data-driven sentence compressors are likely to produce outputs with a compression ratio most commonly seen in the training data references. In other words, CR is less a property of a system and more a characteristic of the dataset. This is supported by the fact that most models reported in the literature have the same compression ratio (in the range of 0.38–0.43, see Table 1).

Secondly, it is not even clear how to treat compression ratio values: is a CR of 0.4 better than a CR of 0.5? Intuitively, yes, because it means a more concise compression. However, the compression is really better only if it retained more valuable information from the source. On the other side, defining the notion of informativeness/importance in sentence compression (and document summarization, in general) is an open problem and currently is not measured automatically. This means that the CR metric is a very one-sided proxy, too crude to be used for real automatic evaluation without balancing it with some recall-oriented metric.

To put the evaluation of our approach into better context, we compare it with the following systems. All systems predict a sequence of binary labels which decide which tokens to keep or remove from the input sentence.

**LSTM.** Filippova et al. (2015) use a three-layer uni-directional Long Short-term Memory (LSTM) network (Hochreiter and Schmidhuber, 1997) and pretrained \textsc{Word2Vec} (Mikolov et al., 2013) embeddings as input representations. For comparison, we use the results for the best configuration reported in the paper (LSTM-PAR-PRES). This system parses the input sentence into a dependency tree, encodes the tree structure and passes the aggregated feature representations to the decoder LSTM. Unlike our approach, this system relies on beam search at inference time.

**BiLSTM.** Wang et al. (2017) build upon LSTM approach, but introduces several modifications. It employs a bi-directional LSTM encoder and enriches the feature representation with syntactic context. In addition, it uses Integer Linear Programming (ILP) methods to enforce explicit constraints on the syntactic structure and sentence length of the output.

**Evaluator-LM.** Zhao et al. (2018) uses a bi-directional RNN to encode the input sentence and predict a binary label for each input token. In addition to token embeddings, the network uses vector representations of part-of-speech (POS) tags and dependency relations. The system is trained using the REINFORCE algorithm (Williams, 1992), the reward signal comes from a pretrained syntax-based language model (LM).
Table 1: The performance of the BERTUni model on the test portion of the Google Dataset, compared to recent approaches. The last row shows BERTUni’s performance on the development set.

| Model               | F1↑   | CR↓   |
|---------------------|-------|-------|
| EVALUATOR-LM        | 0.851 | 0.39  |
| BiLSTM              | 0.800 | 0.43  |
| LSTM                | 0.820 | 0.38  |
| SLAHAN              | 0.855 | 0.407 |
| BERTUni             | 0.857 ± 0.002 | 0.413 ± 0.004 |
| BERTUni (dev)       | 0.860 ± 0.001 | 0.418 ± 0.004 |

SLAHAN. Kamigaito and Okumura (2020) propose a modular sequence-to-sequence model that consists of several components. The system encodes a sequence of tokens using a combination of pretrained embeddings (Glove (Pennington et al., 2014), ELMO (Peters et al., 2018), BERT) and parses the input into a dependency graph. Three attention modules are employed to encode the relations in the graph, their weighted sum is passed to a selective gate. The output of the latter forms an input to a LSTM decoder.

Despite its simplicity, the proposed BERT-based approach achieved very competitive scores (Table 1). Comparing single performance scores (and not score distributions) of neural approaches is meaningless, because training neural models is non-deterministic in many aspects and depends on random weight initialization, random shuffling of the training data for each epoch, applying random dropout masks (Reimers and Gurevych, 2017). This makes it hard to compare the scores reported in previous works and our approach. To facilitate a fair comparison with future systems, we report the mean and standard deviation of the BERTUni scores averaged across ten runs with different random seeds.

In order to understand where BERTUni fails and what we could potentially improve upon, we conducted manual error analysis of its predictions.

4.2 Error analysis

The purpose of error analysis is to find weak spots of a system, from the point of view of human evaluation. In sentence compression, previous work typically analyzed system predictions of the first 200 sentences of the test set, using a 5-point Likert scale to assess annotators’ opinions of the compressions’ readability and informativeness (Filippova et al., 2015).

Since error analysis is used for further system improvement and test sets should be used only for final evaluation, we perform error analysis on the development set. In order to do that, we retrieved BERTUni’s predictions on the 200 dev set sentences which received the lowest F1 scores and manually examined them. Note that those are not random samples; the reason why we chose worst predictions is because we know that the system performed poorly on them.

As for the quality criteria, we had to make certain adjustments. Filippova et al. (2015) mention that readability covers the grammatical correctness, comprehensibility and fluency of the output, while informativeness measures the amount of important content preserved in the compression. In our opinion, merging several criteria into one synthetic index is a bad idea, because annotators can’t easily decide on the exact facet of evaluation. Given that there already exists a problem of distinguishing fluency and grammaticality, adding both of them to assess readability seems to be a bad design decision. The problem is aggravated by the fact that readability as a text quality criterion is already used by NLP researchers for estimating the text complexity from a reader’s point of view (Vajjala and Meurers, 2012; Stajner and Saggion, 2013; Venturi et al., 2015; De Clercq and Hoste, 2016). This made us conclude that readability is another overloaded criterion. Instead, we chose grammaticality as the first quality criterion.

We manually analyzed BERTUni predictions on the 200 aforementioned samples, trying to identify common error patterns. The results are presented below.

Grammaticality. Out of 200 compressions, 146 (73 %) were deemed to be grammatical. The errors in the remaining instances have been classified into several groups (marked with G in Figure 4a).

Most of them were cases where grammatical clauses miss linking words, are stitched together, making
Figure 4: Number of errors made by the evaluated approaches on the 200 development set instances where BERTUnI achieved the lowest F1 scores, as well as errors found in ground-truth compressions. Error types marked with $G$ are grammaticality flaws; the remaining ones are errors of informativeness.

the output ungrammatical, as in the following compressions:

- *I’m said It’s not Kitty Pryde superhero is the leader of the X-Men*.
- *He first Postal Vote result can be announced before 10PM*.

Another large error category was $G$: the compression was grammatical until the last retained token, where the sentence ended abruptly, rendering the compression incomplete:

- *Activision Blizzard has confirmed some new statistics for its games including*.
- *The South Sydney star had no case to*.

A few system outputs incorrectly started with a relative or demonstrative pronoun. This happened when the system failed to retain parts of main clause of the sentence ($rd$-pron):

- *That shows young people rapping while flashing cash and a handgun in a public park*.

Finally, one output missed a verb which was essential for ensuring grammaticality ($verb$-miss):

- *People giant waves crash against the railway line and buildings at Dawlish*.

**Informativeness.** Out of 200 compressions, 105 (52.5 %) were deemed to be informative, the errors in the remaining instances have been classified into several groups (marked with $I$ in Figure4a). Most of these erroneous cases were compressions which missed certain information that was needed for understanding the context ($info$-miss). For example:

- *Dolly Bindra filed a case*.
- *Mount Hope became the third largest city*.

A smaller, but still a large group of compressions started with unresolved personal pronouns, which made it hard to understand the subject ($p$-pron):

- *She hopes her album Britney Jean will inspire people*.
- *He should be allowed to work freely till proven guilty*.

In some cases, omitting the context caused a change in the meaning of the sentence ($mean$-change). For example:

- **Reference:** [...] Aleksandar Vucic [...] voiced hope that Germany will give even stronger support to Serbia [...] 
- **System:** Aleksandar spoke Germany will give stronger support to Serbia.
| Model       | F1↑ | CR↓ |
|------------|-----|-----|
| BERTUni    | **0.860** ±0.001 | 0.418 ±0.004 |
| BERTB1     | 0.849 ±0.001 | 0.423 ±0.005 |
| BERTB1SS   | 0.840 ±0.003 | **0.370** ±0.005 |
| BERTTRI    | 0.847 ±0.002 | 0.423 ±0.007 |
| BERTTRISS  | 0.843 ±0.003 | 0.382 ±0.006 |
| BERTB1-TF  | 0.901 | 0.423 |

Table 2: BERT-based model variants’ performance on the development set (mean and standard deviation across ten random seed values). BERTB1-TF was run only once, since it is a “cheating” model that is not meant to be used in production.

A large number of both grammatical and informative compressions did not match references. Interestingly enough, in some cases the system outputs were better then the references:

- **Reference**: We saw their two and raised to three.
- **System**: Newport beat Hartlepool 2 0.

- **Reference**: Who joins for the remainder of the season subject.
- **System**: Watford have announced the signing of Lucas Neill.

More examples of compression errors are provided in Appendix A.1.

5 Evaluation Discrepancy

When assessing the sentence compressions, we needed to compare system outputs with references. Manual examination revealed that many references themselves were flawed. This, in turn, meant that noise is inherent to the Google Dataset, and metric-based improvements on this data are misleading. To corroborate this claim, we conducted two experiments: the first tested the capacity of a more accurate system to ignore the noise and output compressions of better quality. In the second, we verified whether the noise came from the ground-truth data and attempted to quantify it.

At first, we decided to implement more complex models that could potentially achieve better scores. We attempted to improve the grammatical quality of BERTUni compressions by using the history of model predictions for making more informed decisions.

We implemented and tested models that use BERT-encoded lastly-retained tokens at each prediction step as an additional input to the model (prediction history), similar to n-gram language models. As a history, BERTB1 and BERTTRI used one and two previously predicted tokens, respectively. BERTB1SS and BERTTRISS were the same as BERTB1 and BERTTRI, but used scheduled sampling training scheme to mitigate the exposure bias issue (Bengio et al., 2015).

According to the metric evaluation results, none of the more complex models outperformed BERTUni (Table 2).

We used an unrealistic scenario and artificially made it easier for the model to make correct predictions. We trained a BERTB1-TF model which builds upon BERTB1, but at prediction time for history instead of model predictions uses ground-truth labels. The development set result of BERTB1-TF was an F1 score of **0.901**, a 4-point improvement over BERTUni. We retrieved this model’s predictions for the same 200 dev set sentences used for the error analysis of BERTUni outputs, and manually examined them. The usual evaluation practice is to draw samples randomly, in order to not give an advantage to any system and not to bias the evaluation. However, in this work we approached the problem from a system-development perspective and attempted to assess the comparative performance of the approaches in the worst-case scenario.

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4We call this model BERTB1-TF, since it builds upon BERTB1, but uses teacher forcing (TF) both at training and prediction time.
scenario. If such a comparison is biased, then only in favor of BERT$_{B-I}$, because the drawn samples were the worst ones for BERT$_{UNI}$, not BERT$_{B-I}$. We view this as sanity step, a regression test to ensure that the newer version of the system performs at least as well as the baseline on the challenging cases.

We assessed BERT$_{B-I}$ outputs from the same aspects of grammaticality and informativeness, as described in Section 4.2.

Grammaticality. Out of 200 compressions, only 44 (22 %) were found to be grammatical; we classified the errors in the remaining instances into groups (marked with $G$ in Figure 4b). The first and most prevalent is the already mentioned stitch group which comprises around 80 % of all grammatical errors:

- The program has received FBS college game 2014 season.
- Tskhinvali region with Russia.

The remaining errors are faulty compression endings (finish):

- The fine has been described as a slap on the.
- P Chidambaram sought.

Informativeness. A similar situation was observed when assessing the compressions’ informativeness — only 41 (20.5 %) instances were considered as correct. The distribution of errors (marked with I in Figure 4b) indicates that more than 80 % of cases miss information by omitting important words:

- Dickinson was a.
- Wynalda is mixing.

A smaller fraction of errors was comprised by the cases with unresolved personal pronouns:

- He is an education.
- It would win 45 to 55 seats in Odisha.

The remaining errors were the cases where the system compressions changed the semantics of the input:

- **Sentence**: 612 ABC Mornings intern Saskia Edwards hit the streets of Brisbane to find out what frustrates you about other people.
- **System**: Saskia frustrates people.

More examples of BERT$_{B-I}$ errors are provided in Appendix A.2.

We counted the cases in which predictions of BERT$_{B-I}$ had better or worse quality, compared to BERT$_{UNI}$. In terms of informativeness, BERT$_{B-I}$ improved 15 and worsened 78 instances; in terms of grammaticality, 115 instances were perceived as less grammatical, versus only 13 improved cases, which makes it clear that BERT$_{B-I}$ makes many more mistakes than BERT$_{UNI}$, despite the higher metric scores.

In order to verify our findings, we examined the ground-truth compressions in more detail. Only 63 (31.5 %) of these compressions were both grammatical and informative. Figure 4c shows a visualization of the error type distribution. We provide examples of noisy ground-truth compressions in Appendix A.3.

The abundant errors related to the use of pronouns in the compressions were predominantly caused by the fact that many instances contained ground-truth compressions with unresolved pronouns; cleaning the data would likely result in better outputs.

The stitch, finish and info_miss errors can be attributed to the fact that many references have missing information or artifacts remaining from the automatic procedure that was used to create these compressions (Filippova and Altun, 2013). Resolving these issues may require more elaborate strategies, beyond simple text substitution.
6 Discussion

In this study we advanced the state-of-the-art for the task of sentence compression, and achieved that by designing a simple, but effective sequence labeling system based on the Transformer neural network architecture. While the proposed approach achieved the highest scores reported in the research literature, the main message of the study is not a higher score — it is the idea that NLP system evaluation might need to go beyond simple comparison of metric scores with human judgements.

We found that a higher-scoring system can produce worse-quality outputs. We further provided some empirical evidence that this issue is caused by the noise in the training data. We call this finding a discrepancy discovery, because existent sentence compression work does not explain our results, based on the established evaluation practices. The research papers we analyzed present automatic and human evaluation statistics that seem to overlook the data quality issue. Of course, the approaches proposed so far could still produce high-quality sentence compressions, but the absence of error analysis plants a seed of doubt into the reader. In this work, we question not the reported results, but the principles of the conventional evaluation workflow.

None of the examined research papers drew attention to the quality of the data, even though it is known that the dataset was constructed automatically, and therefore should contain noisy examples, which should affect the output quality of any data-driven system. Previous work also overlooked the use of the compression ratio which seems to be too simplistic to call it a metric that measures the compression effectiveness. Finally, the employed sentence compression evaluation protocols do not assume having multiple references. We did not go into much detail about this issue, but provided an illustration at the beginning of the paper (the Dickson example). The space of possible compressions in deletion-based sentence compression is bound by sentence length. But because the definition of importance is left out, the candidate space is very large. The existence of only one reference brings additional requirements for evaluation metrics to work, and commonly used n-gram overlap metrics clearly do not satisfy these requirements.

7 Conclusion

The presented results show that system output analysis is indispensable when assessing the quality of NLP systems. It is a well-established fact that metric scores used for system development do not always reflect the actual quality of a system; usually this is revealed via human evaluation experiments. However, in our case study of automatic sentence compression we have discovered that they might not be sufficient. Further investigation is needed to make stronger claims; the study’s findings are yet to be confirmed for other datasets and, perhaps, tasks.

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A Error Examples

This section contains error examples of BERT Uni and BERT Bi-TF models, as well as errors in the gold standard. We publicly share the prediction and error analysis files at https://github.com/UKPLab/arxiv2021-evaluation-discrepancy-nsc.

Grammaticality. Error types:

- finish: incomplete sentence with an abrupt ending, caused by omitting the last token(s);
- stitch: grammatical clauses with missing linking words, as if they are stitched together, which renders the sentence ungrammatical;
- rd-pron: incorrect sentence start with a relative or demonstrative pronoun;
- verb-miss: missing a verb which is essential for ensuring the grammaticality of a sentence.

Informativeness. Error types:

- info-miss: missing certain information that is needed for understanding the context;
- p-pron: starting with an unresolved personal pronoun, which makes it hard to understand the subject;
- mean-change: omitting the context causing a change of the meaning of the sentence.

We also provide examples of alternative compressions which focus on parts of the input sentence, which are different from those present in the reference compressions. They are marked with an I2 label and are listed here, together with erroneous cases, because due to mismatches with references they lower the metric scores of the evaluated approaches.

A.1 BERT Uni

Grammatical Errors

| Error     | Sentence                                                                 | Compression                                      |
|-----------|---------------------------------------------------------------------------|--------------------------------------------------|
| finish    | A young cow trying to grab a cooling drink from a river in Hampshire in    | A cow trying to grab a drink had rescued         |
|           | the hot weather had to be rescued by firefighters when it got stuck in the |
|           | mud.                                                                      |                                                  |
Japan and the US reaffirmed Monday during a meeting in Tokyo with visiting Under Secretary for Terrorism and Financial Intelligence David S Cohen their ongoing cooperation on sanctions against Iran, a Japanese government source said Tuesday.

612 ABC Mornings intern Saskia Edwards hit the streets of Brisbane to find out what frustrates you about other people. Google Helpouts, which was launched this week, is a service that allows you to pay for brief one-on-one webcam master classes with a range of experts in various fields.

Table 3: Manual error analysis results: examples of ungrammatical outputs of BERTUNI.

| Error   | Sentence                                                                 | Compression                  |
|---------|--------------------------------------------------------------------------|------------------------------|
| info-miss | Buyers should beware, even though there was a safety recall on some GM cars those are still being sold on Craigslist. New results show some improvement in test scores and graduation rates for local students, but experts say there’s still more work to be done. Counting of postal votes have already commenced while Elections Commissioner Mahinda Deshapriya stated that he first Postal Vote result can be announced before 10PM. When President Obama was elected in 2008 for his first term, he made a presidential decision that he would not give up his blackberry. | Buyers should beware. There’s still more work to be done. He first Postal Vote result can be announced before 10PM. He would not give up his blackberry. |
| mean-change | On this week’s “Hostages” season 1, episode 13: “Fight or Flight,” Ellen reveals to Duncan that she will not kill the President but will help him get what he needs, as long as he gives her something in return. Serbia’s First Deputy Prime Minister Aleksandar Vucic spoke in Germany with former German chancellor Helmut Kohl about Serbia’s path towards the EU and its economic recovery/ During the talks, Vucic highlighted the important role of German investors in Serbia and voiced hope that Germany will give even stronger support to Serbia in the realisation of its European goals. | Ellen reveals she will not kill the President. Aleksandar spoke Germany will give stronger support to Serbia. |
| p-pron | “Being a five-time champion, he knows how to handle pressure. Anand generally puts a lid on his emotions.” Chelsea manager Jose Mourinho has made light of the managerial instability under Roman Abramovich by admitting he’s trying to break his own record. | He knows how to handle pressure. He’s trying to break his own record. |
Katy Perry wasn’t lying when she said she had some “beautiful news to share,” because she is now the new face of COVERGIRL.

I2

Provisur Technologies has entered into an agreement with Scanico in which Scanico has become Provisur’s global partner in commercial freezing technology.

Davina McCall has undergone medical tests after fears she may be suffering from hypothermia after battling severe weather in a Sport Relief challenge.

Reference: Scanico has become Provisur’s global partner in commercial freezing technology.
System: Provisur Technologies has entered into an agreement with Scanico.
Reference: she may be suffering from hypothermia after battling in a Sport Relief challenge.
System: Davina McCall has undergone medical tests.

Table 4: Manual error analysis results: examples of uninformative outputs of BERTUNI. We also show examples of alternative compressions (I2) which deviate from ground-truth compressions, but cannot be considered as errors.

A.2 BERTBi-TF

Grammatical Errors

| Error | Sentence                                                                 | Compression                                                                                           |
|-------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| finish | A UKIP candidate who is standing for election in Enfield Town has defended a tweet in which he said a black comedian “should emigrate to a black country.” | UKIP candidate has defended a tweet he said a black comedian should                                 |
|        | Wynalda, who was introduced as the Silverbacks’ new manager on Tuesday, is mixing a bit of Europe with a bit of Mexico with a bit of Silicon Valley in an approach that will eliminate the head-coaching position. | Wynalda is mixing.                                                                                   |
|        | Cell C has announced new pre-paid and contract packages that offer unlimited calls to any network. | Cell C has announced.                                                                                  |
|        | Radnor police received a report Sept. 3 from a cadet at Valley Forge Military Academy that another cadet struck him in the face. | Radnor police received a report another.                                                               |
|        | Diego Forlan scored directly from a corner this weekend to help Internacionals to a 3-2 win over Fluminense. | Diego Forlan scored to help Internacionals to.                                                        |
|        | This 1930s-built four bedroom detached seafront home in Worting is immaculately presented and has been expertly modernised. | This seafront home is.                                                                                |

stitch

| Error | Sentence                                                                                           | Compression                                                                                           |
|-------|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
|        | Buyers should beware, even though there was a safety recall on some GM cars those vehicles are still being sold on Craigslist. | Buyers should beware are being sold on Craigslist.                                                     |
|        | Davina McCall has undergone medical tests after fears she may be suffering from hypothermia after battling severe weather in a Sport Relief challenge. | Davina McCall has undergone tests be suffering from hypothermia.                                      |
|        | New results show some improvement in test scores and graduation rates for local students, but experts say there’s still more work to be done. | Show some improvement in test scores graduation rates students but there.                             |
|        | POLICE are looking for witnesses after a car was hit by a van which failed to stop on Friday, January 7. | POLICE a.                                                                                             |
|        | Our obsession with Sachin Tendulkar and records has made us lose perspective to such an extent that what should have been widely condemned is being conveniently ignored. | With Sachin Tendulkar has made lose perspective what.                                                 |
|        | Watford have this evening announced the signing of experienced defender Lucas Neill, who joins for the remainder of the season subject to international clearance. | Watford announced the signing Lucas season.                                                           |

Table 5: Manual error analysis results: examples of ungrammatical outputs of BERTBi-TF

Informativeness Errors

| Error | Sentence                                                                                           | Compression                                                                                           |
|-------|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
|        |                                                                                                   |                                                                                                       |
“Former President Mandela is still in a critical condition in hospital but shows sustained improvement,” President Jacob Zuma said in a statement. This 1930s-built four bedroom detached seafront home in Worthing is immaculately presented and has been expertly modernised. ASI’s additional director general BR Mani said he was hopeful of Nalanda making it to the list, claiming that Nalanda was an important centre of art and culture even before the university came into being. Tata Martino explained that after two months in Barcelona, he is starting to understand how things work at the club, assuring that there seems to be a need to create a weekly crisis regarding the team’s style of play.

Provisur Technologies has entered into an agreement with Scanico in which Scanico has become Provisur’s global partner in commercial freezing technology. TV presenter Katie Piper shows off her baby daughter for the first time and said motherhood has given her “true fulfillment”. AFL powerbrokers yesterday met Collingwood officials over convicted criminal Marley Williams, who faces a possible club ban or even a league suspension. British rapper Professor Green was arrested on suspicion of drink driving on Sunday after he called police to report a robbery.

“Being a five-time champion, he knows how to handle pressure. Anand generally puts a lid on his emotions.”

On this week’s “Hostages” season 1, episode 13: “Fight or Flight,” Ellen reveals to Duncan that she will not kill the President but will help him get what he needs, as long as he gives her something in return.

Blustery winds arrived in Gwinnett on Wednesday and brought with them lower temperatures that caused the National Weather Service to issue a freeze warning for the area.

BJP and JD today welcomed the five-year jail term handed down to RJD chief Lalu Prasad in the fodder scam case, saying it would send out a message that the law will catch up with the corrupt, however influential they might be.

Table 6: Manual error analysis results: examples of uninformative outputs of BERTBi-TF. We also show examples of alternative compressions (I2) which deviate from ground-truth compressions, but cannot be considered as errors.

A.3 Ground Truth

Grammatical Errors

| Error | Sentence | Compression |
|-------|----------|-------------|
| finish | Police investigating the unexplained death of a man in Taupo say his van appears to have broken down. Akkineni Nageswara Rao was one of the Indian cinema’s stalwarts, who will be remembered for his rich contribution. Mortgage fees are going up so where does Pa. | Police investigating the unexplained death say. Akkineni Nageswara Rao was one. Where does Pa. |
Coffee chain Starbucks has said guns are no longer “welcome” in its US cafes, although it has stopped short of an outright ban.

Starbucks has said guns are not longer "welcome" in its US cafes, although it has stopped short of an outright ban.

rd-pron Way back in May 2011, Google filed a patent application for eye tracking technology, which would allow it to charge advertisers on a ‘pay per gaze’ basis.

Which would allow it to charge advertisers on a pay per gaze basis.

POLICE are looking for witnesses after a car was hit by a van which failed to stop on Friday, January 7.

Which failed to stop.

Tomorrow South Africa will celebrate the centenary of the Union Buildings in Pretoria which have recently been declared a national heritage site by the South African Heritage Resources Agency.

Which have been declared a national heritage site.

In a press release, Patrick said Goldstein will be replaced by Rachel Kapieliani, who is currently the state’s registrar of motor vehicles.

Who is the state’s registrar.

Informativeness Errors

| Error | Sentence | Compression |
|-------|----------|-------------|
| info-miss | Some parents and others in Bessemer City are complaining about a YouTube video that shows young people rapping while flashing cash and a handgun in a public park. Tata Martino explained that after two months in Barcelona, he is starting to understand how things work at the club, assuring that there seems to be a need to create a weekly crisis regarding the team’s style of play. Nothing is ever left behind in a BREACHED performance as the loud rocking, heavy amp cranky band announce Toronto show dates since performing last October at Indie Week. Prime Minister Kevin Rudd has missed the deadline for an August 24 election, with his deputy saying “people should just chill out” about the election date. | Some parents in Bessemer City are complaining about a video. There seems to be a need to create a weekly crisis. Band announce Toronto show dates. People should chill out about the election date. |
| p-pron | Davina McCall has undergone medical tests after fears she may be suffering from hypothermia after battling severe weather in a Sport Relief challenge. TV presenter Nick Knowles has been the recipient of some unexpected abuse as a result of an announcement that he will not be present at the birth of his child. England fast bowler James Anderson does not feel sorry for Australia and has said his team wants to win the Ashes 5-0. If he decides to run for president, New Jersey Gov. Chris Christie will need to push back against the inevitable pressure that he will encounter to move to the right. Armaan will be taken for a medical examination and post that he will be presented in the court today. | She may be suffering from hypothermia after battling in a Sport Relief challenge. He will not be present at the birth. His team wants to win the Ashes 5-0. He will encounter to move to the right. He will be presented in the court today. |

Table 7: Manual error analysis results: examples of grammatical errors in ground-truth compressions, sampled from 200 development set instances with lowest BERT Uni F1 scores.

Table 8: Manual error analysis results: examples of informativeness errors in ground-truth compressions, sampled from 200 development set instances with lowest BERT Uni F1 scores.)