

HIGHRES: Highlight-based Reference-less Evaluation of Summarization

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Abstract

There has been substantial progress in summarization research enabled by the availability of novel, often large-scale, datasets and recent advances on neural network-based approaches. However, manual evaluation of the system generated summaries is inconsistent due to the difficulty the task poses to human non-expert readers. To address this issue, we propose a novel approach for manual evaluation, HIGHLIGHT-based Reference-less Evaluation of Summarization (HIGHRES), in which summaries are assessed by multiple annotators against the source document via manually highlighted salient content in the latter. Thus summary assessment on the source document by human judges is facilitated, while the highlights can be used for evaluating multiple systems. To validate our approach we employ crowd-workers to augment with highlights a recently proposed dataset and compare two state-of-the-art systems. We demonstrate that HIGHRES improves inter-annotator agreement in comparison to using the source document directly, while they help emphasize differences among systems that would be ignored under other evaluation approaches¹.

1 Introduction

Research in automatic summarization has made headway over the years with single document summarization as the front-runner due to the availability of large datasets (Sandhaus, 2008; Hermann et al., 2015; Narayan et al., 2018b) which has enabled the development of novel methods, many of them employing recent advances in neural networks (See et al., 2017; Narayan et al., 2018c; Pasunuru and Bansal, 2018, *inter alia*).

Measuring progress in summarization is difficult, as the task has as input a source document

¹Our dataset and code are available at <https://github.com/sheffieldnlp/highres>

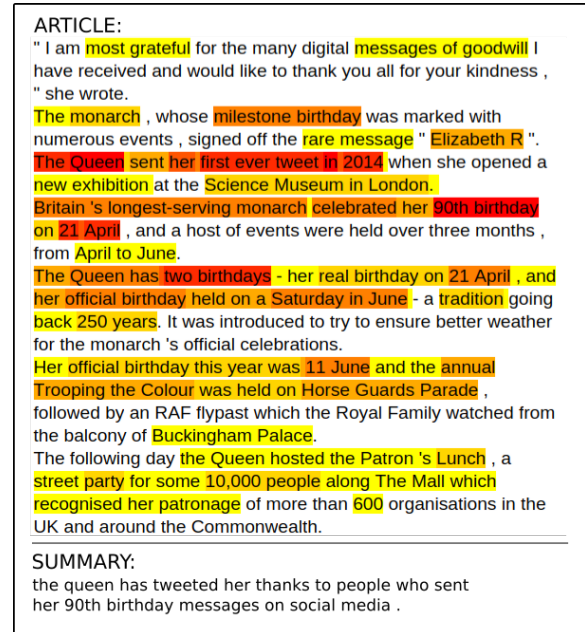


Figure 1: Highlight-based evaluation of summaries. Annotators to evaluate a summary (bottom) against the highlighted source document (top) presented with a heat map marking the salient content in the document; the darker the colour, the more annotators deemed the highlighted text salient.

consisting of multiple sentences and methods need to generate a shorter text that expresses the salient information of the source fluently and succinctly. Thus there can be multiple equally good summaries for the same source document as not all salient information can fit in a given summary length, while even extractive methods that select complete sentences are not guaranteed to produce a coherent summary overall.

The most consistently used evaluation approach is comparison of the summaries produced against reference summaries via automatic measures such as ROUGE (Lin, 2004) and its variants. However, automatic measures are unlikely to be sufficient to measure performance in summarization (Schluter,

2017), also known for other tasks in which the goal is to generate natural language (Novikova et al., 2017). Furthermore, the datasets typically considered have a single reference summary, as obtaining multiple ones increases dataset creation cost, thus evaluation against them is likely to exhibit reference bias (Louis and Nenkova, 2013; Fomicheva and Specia, 2016), penalizing summaries containing salient content different from the reference.

For the above reasons manual evaluation is considered necessary for measuring progress in summarization. However, the intrinsic difficulty of the task has led to research without manual evaluation or only fluency being assessed manually. Those that conduct manual assessment of the content, typically use a single reference summary, either directly (Celikyilmaz et al., 2018; Tan et al., 2017) or through questions (Narayan et al., 2018b,c) and thus are also likely to exhibit reference bias.

In this paper we propose a novel approach for manual evaluation, HIGHLIGHT-based Referenceless Evaluation of document Summarization (HIGHRES), in which a summary is assessed against the source document via manually highlighted salient content in the latter (see Figure 1 for an example). Our approach avoids reference bias, as the multiple highlights obtained help consider more content than what is contained in a single reference. The highlights are not dependent on the summaries being evaluated but only on the source documents, thus they are reusable across studies, and they can be crowd-sourced more effectively than actual summaries. Furthermore, we propose to evaluate the clarity of a summary separately from its fluency, as they are different dimensions. Finally, HIGHRES provides absolute instead of ranked evaluation, thus the assessment of a system can be conducted and interpreted without reference to other systems.

To validate our proposed approach we use the recently introduced eXtreme SUMmarization dataset (XSUM, Narayan et al., 2018b) to evaluate two state-of-the-art abstractive summarization methods, Pointer Generator Networks (See et al., 2017) and Topic-aware Convolutional Networks (Narayan et al., 2018b), using crowd-sourcing for both highlight annotation and quality judgments. We demonstrate that HIGHRES improves inter-annotator agreement in comparison to using the source document directly, while they help emphasize differences among systems that would be ig-

nored under other evaluation approaches, including reference-based evaluation. Furthermore, we show that the clarity metric from the DUC (Dang, 2005) must be measured separately from “fluency”, as judgments for them had low correlation. Finally, we make the highlighted XSUM dataset, codebase to replicate the crowd-sourcing experiments and all other materials produced in our study publicly available.

2 Literature Review

In recent years, summarization literature has investigated different means of conducting manual evaluation. We study a sample of 26 recent papers from major ACL conferences and outline the trends of manual evaluation in summarization in Table 1. From 26 papers, 11 papers (e.g., See et al., 2017; Kedzie et al., 2018; Cao et al., 2018) did not conduct any manual evaluation, they are not shown in Table 1.² Following the Document Understanding Conference (DUC) (Dang, 2005), a majority of work has focused on evaluating the content and the linguistic quality of summaries (Nenkova, 2005). However, there seems to be a lack of consensus on how a summary should be evaluated: (i) Should it be evaluated relative to other summaries or standalone in absolute terms? and (ii) What would be a good source of comparison: the input document or the reference summary? The disagreements on these issues result in authors evaluating their summaries often (11 out of 26 papers) using automatic measures such as ROUGE (Lin, 2004) despite of its limitations (Schluter, 2017). In what follows, we discuss previously proposed approaches along three axes: evaluation metrics, relative vs. absolute, and the choice of reference.

Evaluation Metrics Despite differences in the exact definitions, the majority (e.g., Hsu et al., 2018; Celikyilmaz et al., 2018; Narayan et al., 2018b; Chen and Bansal, 2018; Peyrard and Gurevych, 2018) agree on both or either one of two broad quality definitions: *coverage* determines how much of the salient content of the source document is captured in the summary, and *informativeness*, how much of the content captured in the summary is salient with regards to the original document. These measures correspond to “*recall*” and “*precision*” metrics respec-

²A complete table from this study can be found in the supplementary material.

Systems	Pyramid	QA	Correctness	Fluency	Clarity	Recall	Precision	Absolute	Relative	With Reference	With Document	With Ref. & Doc.
Celikyilmaz et al. (2018)						✓	✓	✓	✓	✓	✓	
Chen and Bansal (2018)			✓			✓	✓	✓	✓			✓
Guo et al. (2018)				✓			✓		✓			✓
Hardy and Vlachos (2018)				✓				✓				
Hsu et al. (2018)				✓		✓	✓	✓			✓	
Krishna and Srinivasan (2018)						✓			✓		✓	
Kryściński et al. (2018)				✓		✓		✓			✓	
Li et al. (2018b)			✓					✓				
Narayan et al. (2018a)				✓					✓		✓	
Narayan et al. (2018b)		✓		✓		✓		✓	✓	✓	✓	
Narayan et al. (2018c)		✓		✓		✓		✓	✓	✓	✓	
Peyrard and Gurevych (2018)						✓	✓	✓		✓		
ShafieiBavani et al. (2018)	✓											
Song et al. (2018)			✓	✓		✓		✓			✓	
Yang et al. (2017)						✓			✓	✓		
HIGHRES (ours)				✓	✓	✓	✓	✓			✓	

Table 1: Overview of manual evaluations conducted in recent summarization systems. We categorize them in three dimensions: the first column identifies matrices used for evaluating content (“Pyramid”, “QA”, “Correctness”, “Recall” and “Precision”) and quality (“Clarity”, “Fluency”) of summaries; the second column focuses if the system ranking reported by humans on content evaluation were “Absolute” or “Relative”; and finally, the third column evaluates if summaries were evaluated against the input document (“With Document”), the reference summary (“With Reference”) or both (“With Ref. & Doc.”).

tively in Table 1, notions that are commonly used in information retrieval and information extraction literature. Clarke and Lapata (2010) proposed a question-answering based approach to improve the agreement among human evaluations for the quality of summary content, which was recently employed by Narayan et al. (2018b) and Narayan et al. (2018c) (QA in Table 1). In this approach, questions were created first from the reference summary and then the system summaries were judged with regards to whether they enabled humans to answer those questions correctly. ShafieiBavani et al. (2018), on the other hand, used the “Pyramid” method (Nenkova and Passonneau, 2004) which requires summaries to be annotated by experts for salient information. A small number of work evaluates the “Correctness” (Chen and Bansal, 2018; Li et al., 2018b; Chen and Bansal, 2018) of the summary, similar to fact checking (Vlachos and Riedel, 2014), which can be a challenging task in its own right.

The linguistic quality of a summary encompasses many different qualities such as fluency, grammatically, readability, formatting, naturalness and coherence. Most recent work uses a single human judgment to capture all linguistic qualities of the summary (Hsu et al., 2018; Kryściński et al.,

2018; Narayan et al., 2018b; Song et al., 2018; Guo et al., 2018); we group them under “Fluency” in Table 1 with an exception of “Clarity” which was evaluated in the DUC evaluation campaigns (Dang, 2005). The “Clarity” metric puts emphasis in easy identification of noun and pronoun phrases in the summary which is a different dimension than “Fluency”, as a summary may be fluent but difficult to be understood due to poor clarity.

Absolute vs Relative Summary Ranking. In relative assessment of summarization, annotators are shown two or more summaries and are asked to rank them according to the dimension at question (Yang et al., 2017; Chen and Bansal, 2018; Narayan et al., 2018a; Guo et al., 2018; Krishna and Srinivasan, 2018). The relative assessment is often done using the paired comparison (Thurstone, 1994) or the best-worst scaling (Woodworth and G, 1991; Louviere et al., 2015), to improve inter-annotator agreement. On the other hand, absolute assessment of summarization (Li et al., 2018b; Song et al., 2018; Kryściński et al., 2018; Hsu et al., 2018; Hardy and Vlachos, 2018) is often done using the Likert rating scale (Likert, 1932) where a summary is assessed on a numerical scale. Absolute assessment was also employed

in combination with the question answering approach for content evaluation (Narayan et al., 2018b,c). Both approaches, relative ranking and absolute assessment, have been investigated extensively in Machine Translation (Bojar et al., 2016, 2017). Absolute assessment correlates highly with the relative assessment without the bias introduced by having a simultaneous assessment of several models (Bojar et al., 2011).

Choice of Reference. The most convenient way to evaluate a system summary is to assess it against the reference summary (Celikyilmaz et al., 2018; Yang et al., 2017; Peyrard and Gurevych, 2018), as this typically requires less effort than reading the source document. The question answering approach of Narayan et al. (2018b,c) also falls in this category, as the questions were written using the reference summary. However, summarization datasets are limited to a single reference summary per document (Sandhaus, 2008; Hermann et al., 2015; Grusky et al., 2018; Narayan et al., 2018b) thus evaluations using them is prone to reference bias (Louis and Nenkova, 2013), also a known issue in machine translation evaluation (Fomicheva and Specia, 2016). A circumvention for this issue is to evaluate it against the source document (Song et al., 2018; Narayan et al., 2018a; Hsu et al., 2018; Kryściński et al., 2018), asking judges to assess the summary after reading the source document. However this requires more effort and is known to lead to low inter-annotator agreement (Nenkova and Passonneau, 2004).

3 HIGHRES

Our novel highlight-based reference-less evaluation does not suffer from reference bias as a summary is assessed against the source document with manually highlighted salient content. These highlights are crowd-sourced effectively without the need of expert annotators as required by the Pyramid method (Nenkova and Passonneau, 2004) or to generate reference summaries. Our approach improves over the “Correctness” or “Fluency” only measure for summarization by taking salience into account. Finally, the assessment of summaries against the document with highlighted pertinent content facilitates an absolute evaluation of summaries with high inter-annotator agreement.

Our evaluation framework comprises three main components: document highlight annotation,

highlight-based content evaluation, and clarity and fluency evaluation. The second component, which evaluates the notions of “Precision” and “Recall” requires the highlights from the first one to be conducted. However, the highlight annotation needs to happen only once per document, and it can be reused to evaluate many system summaries, unlike the Pyramid approach (Nenkova and Passonneau, 2004) that requires additional expert annotation for every system summary being evaluated. The third component is independent of the others and can be run in isolation. In all components we employ crowd-workers as human judges, and implement appropriate sanity checking mechanisms to ensure good quality judgements. Finally, we present an extended version of ROUGE (Lin, 2004) that utilizes the highlights to evaluate system summaries against the document; this demonstrates another use of the highlights for summarization evaluation.

3.1 Highlight Annotation

In this part, we ask human judges to read the source document and then highlight words or phrases that are considered salient. Each judge is allowed to highlight parts of the text at any granularity, from single words to complete sentences or even paragraphs. However we enforce a limit in the number of words to K that can be highlighted in total by a judge in a document, corresponding to the length of the summary expected. By employing multiple judges per document who are restricted in the amount of text that can be highlighted we expect to have a more diverse and focused highlight from multiple judges which cover different viewpoints of the article.

To ensure that each highlight is reliable, we performed a sanity check at the end of the task where we ask the judges to answer a True/False question based on the article. We rejected all annotations that failed to correctly answer the sanity check question.

3.2 Highlight-based Content Evaluation

In this component, we present human judges a document that has been highlighted using heatmap coloring and a summary to assess (see Figure 1 for an example). We ask our judges to assess the summary for (i) ‘*All important information is present in the summary*’ and (ii) ‘*Only important information is in the summary*.’ The first one is the recall (content coverage) measure and the second, the

precision (informativeness) measure. All the ratings were collected on a 1-100 Likert scale (Likert, 1932). Figure ?? shows the screen that is presented to judges where salient parts of the document are highlighted.

As with the highlight annotation, we performed the same form of sanity check to the one in the highlight annotation task.

3.3 Clarity and Fluency Evaluation

In this part, we give the judges only the summary and ask them to rate it on clarity and fluency. For *clarity*, each judge is asked whether the summary is easy to be understood, i.e. there should be no difficulties in identifying the referents of the noun phrases (every noun/place/event should be well-specified) or understanding the meaning of the sentence. For *fluency*, each judge is asked whether the summary sounds natural and has no grammatical problems. While fluency is often evaluated in recent work, clarity, while first introduced in DUC evaluations, has recently been ignored in manual evaluation, despite that it captures a different dimension of summarization quality.

To ensure that the judgments for clarity and fluency are not affected by each other (poor fluency can affect clarity, but a summary can have perfect fluency but low clarity), we evaluate each metric separately. We ask the judges to evaluate multiple summaries per task with each dimension in its own screen. For sanity checking, we insert three fake summary with different qualities (good, mediocre and bad summaries). We reject results where the numeric scores given by annotators failed to pass this criteria: bad < mediocre < good.

3.4 Highlight-based ROUGE Evaluation

Our Highlight-based ROUGE (we refer to it as HROUGE) formulation is similar to the original ROUGE with the difference that the n-grams are weighted by the number of times they were highlighted. One benefit of HROUGE is that it introduces saliency into the calculation without being reference-based as in ROUGE. Implicitly HROUGE considers multiple summaries as the highlights are obtained from multiple workers.

Given a document \mathcal{D} as a sequence of m tokens $\{w_1, \dots, w_m\}$, annotated with \mathcal{N} highlights, we

define the weight $\beta_g^n \in [0, 1]$ for an n -gram g as:

$$\beta_g^n = \frac{\sum_{i=1}^{m-(n-1)} \left[\frac{\sum_{j=i}^{i+n-1} \frac{\text{NumH}(w_j)}{\mathcal{N}}}{n} \right]_{w_{i:i+n-1}=g}}{\sum_{i=1}^{m-(n-1)} [1]_{w_{i:i+n-1}=g}}$$

where, $[x]_y$ is an indicator function which returns x if y is true and 0, otherwise. $\text{NumH}(w_j) = \sum_{k=1}^{\mathcal{N}} \frac{\text{len}(H_k)}{\mathcal{K}} [1]_{w_j \in H_k}$ is a function which returns the number of times word w_j is highlighted by the annotators out of \mathcal{N} times weighted by the lengths of their highlights; H_k is the highlighted text by the k th annotator and \mathcal{K} is the maximum allowed length of the highlighted text (see Section 3.1). $\text{NumH}(w_j)$ gives less importance to annotators with highlights with few words. In principle, if an n -gram is highlighted by every crowd-worker and the length of the highlight of each crowd-worker is \mathcal{K} , the n -gram g will have a maximum weight of $\beta_g^n = 1$. The HROUGE scores for a summary \mathcal{S} can then be defined as:

$$\begin{aligned} \text{HR}_{\text{rec}}^n &= \frac{\sum_{g \in n\text{-gram}(\mathcal{S})} \beta_g^n \text{count}(g, \mathcal{D} \cap \mathcal{S})}{\sum_{g \in n\text{-gram}(\mathcal{D})} \beta_g^n \text{count}(g, \mathcal{D})} \\ \text{HR}_{\text{pre}}^n &= \frac{\sum_{g \in n\text{-gram}(\mathcal{S})} \beta_g^n \text{count}(g, \mathcal{D} \cap \mathcal{S})}{\sum_{g \in n\text{-gram}(\mathcal{S})} \text{count}(g, \mathcal{S})} \end{aligned}$$

HR_{rec}^n and HR_{pre}^n are the HROUGE recall and precision scores; $\text{count}(g, \mathcal{X})$ is the maximum number of n -gram g occurring in the text \mathcal{X} . The weight in the denominator of HR_{pre}^n is uniform ($\beta_g^n = 1$) for all g because if we weighted according to the highlights, words in the summary that are not highlighted in the original document would be ignored. This would result in HR_{pre}^n not penalizing summaries for containing words that are likely to be irrelevant as they do not appear in the highlights of the document. It is important to note HROUGE has an important limitation in that it penalizes abstractive summaries that do not reuse words from the original document. This is similar to ROUGE penalizing summaries for not reusing words from the reference summaries, however the highlights allow us to implicitly consider multiple references without having to actually obtain them.

Instructions & Controls

Your task is to assess the quality of the summary based on the document and its highlights.

Hover the mouse on top of **?** to see more information.

Words that are important in the document have been highlighted using heatmap coloring (Darker color signifies higher importance). You have to decide which importance level that signifies the informativeness of words.

Use the slider to remove light color (less important highlights) by sliding it to the right. The number tells you how many color you can remove until there is only one color (the most important words) left.

The 88-year-old Dutchman was appointed in March, when the Black Cats were one point above the relegation zone.

He guided them to safety and was due to leave the club in the summer, only to sign a new one-year contract.

Advocaat said: "I have made the decision to go after only eight games as I felt it was important to give everyone time to turn things around."

Sunderland chairman Ellis Short said: "I am truly saddened by Dick's decision, but I respect him for his honesty."

Media playback is not supported on this device. It is also testament to his character that he has foregone any kind of a financial settlement, something which is very unusual in football."

Assistant head coach Zeljko Petrovic has also left the club.

Saturday's draw with West Ham left Sunderland without a win in their first eight league matches and looking for a sixth manager in four years.

Since Steve Bruce was sacked in November 2011, Martin O'Neill, Paolo di Canio, Gus Poyet and Advocaat have managed the club.

Advocaat's departure also follows a trend set by Di Canio and Poyet of managers arriving to save the Black Cats from the drop, only to depart in the next season.

He initially agreed to lead Sunderland only until the end of last season, shedding tears as their survival was secured with a 0-0 draw at Arsenal.

Advocaat said he would leave the club to fulfil a promise to his wife, but changed his mind and returned in June.

The former Netherlands, Russia and South Korea boss has seen his side win just once this season - against League Two Exeter in the League Cup.

North-east rivals Newcastle are the only team below them in the Premier League table.

Assessment

Assess the following summary.

dick advocaat has resigned as sunderland manager until the end of the season .

How strongly agree are you on the following statements?

All important information is present in the summary

Strongly disagree Strongly agree

Only important information is in the summary.

Strongly disagree Strongly agree

[Click to submit](#)

Figure 2: The UI for content evaluation with highlight. Judges are given an article with important words highlighted using heat map. Judges can also remove less important highlight color by sliding the scroller at the left of the page. At the right of the page judges give the recall and precision assessment by sliding the scroller from 1 to 100 based on the given summary quality.

4 Summarization Dataset and Models

We use the extreme summarization dataset (XSUM, Narayan et al., 2018b)³ which comprises BBC articles paired with their single-sentence summaries, provided by the journalists writing the articles. The summary in the XSUM dataset demonstrates a larger number of novel n -grams compared to other popular datasets such as CNN/DailyMail (Hermann et al., 2015) or NY Times (Sandhaus, 2008) as such it is suitable to be used for our experiment since the more abstractive nature of the summary renders automatic methods such as ROUGE less accurate as they rely on string matching, and thus calls for human evaluation for more accurate system comparisons. Following Narayan et al. (2018b), we didn't use the whole test set portion, but sampled 50 articles from it for our highlight-based evaluation.

We assessed summaries from two state-of-the-art abstractive summarization systems using our highlight-based evaluation: (i) the Pointer-Generator model (PTGEN) introduced by See et al. (2017) is an RNN-based abstractive systems which allows to copy words from the source text, and (ii) the Topic-aware Convolutional Sequence to Sequence model (TCONVS2S) introduced by

³<https://github.com/EdinburghNLP/XSum>

Narayan et al. (2018b) is an abstractive model which is conditioned on the article's topics and based entirely on Convolutional Neural Networks. We used the pre-trained models⁴ provided by the authors to obtain summaries from both systems for the documents in our test set.

5 Experiments and Results

All of our experiments are done using the Amazon Mechanical Turk platform. We develop three types of Human Intelligence Tasks (HITs): highlight annotation, highlight-based content evaluation, and fluency and clarity evaluation. In addition, we elicited human judgments for content evaluation in two more ways: we assessed system summaries against the original document (without highlights) and against the reference summary. The latter two experiments are intended as the comparison for our proposed highlight-based content evaluation.

5.1 Highlight Annotation

We collected highlight annotations from 10 different participants for each of 50 articles. For each annotation, we set K , the maximum number of

⁴Both models were trained using the standard cross-entropy loss to maximize the likelihood of the reference summary given the document.

words to highlight, to 30. Our choice reflects the average length (24 words) of reference summaries in the XSUM dataset. To facilitate the annotation of BBC news articles with highlights, we asked our participants to adapt the 5W1H (Who, What, When, Where, Why and How) principle (Robertson, 1946) that is a common practice in journalism. The participants however were not obliged to follow this principle and were free to highlight content as they deem fit.

The resulting annotation exhibits a substantial amount of variance, confirming the intuition that different participants are not expected to agree entirely on what is salient in a document. On average, the union of the highlights from 10 annotators covered 38.21% per article and 33.77% of the highlights occurred at the second half of the article. This shows that the judges did not focus only on the beginning of the documents but annotated all across the document.

Using Fleiss Kappa (Fleiss, 1971) on the binary labels provided by each judge on each word (highlighted or not) we obtained an average agreement of 0.19 for the 50 articles considered. The low agreement score does not indicate a poor annotation process necessarily; we argue that this is primarily due to the annotators having different opinions on which parts of an article are salient. The article with the highest agreement (0.32) has more focused highlights, whereas the article with the lowest agreement (0.04) has highlights spread all over (both articles can be seen in the supplementary materials). Interestingly, the reference summary on the highest agreement article appears to be more informative of its content when the annotator agreement is high; the reference summary on the lowest agreement article is more indicative, i.e., it doesn't contain any informative content from the article but only to inform the reader about the article's topic and scope. These results confirm that the annotation behaviour originates from the nature of the document and the summary it requires, and validates our highlight annotation setup.

5.2 Content Evaluation of Summaries

We assessed the summaries against (i) documents with highlights (Highlight-based), (ii) original documents without highlights (Non Highlight-based) and (iii) reference summaries (Reference-based). For each setup, we collected judgments

Model	Highlight-based		Non Highlight-based		Reference-based	
	Prec	Rec	Prec	Rec	Prec	Rec
TCONVS2S	57.42	49.95	52.55	41.04	46.75	36.45
PTGEN	50.94	44.41	48.57	39.21	44.24	38.24
Reference	67.90	56.83	66.01	52.45	—	—

Table 2: Results of content evaluation of summaries against documents with highlights, documents without highlights and reference summaries.

Model	Highlight-based		Non Highlight-based	
	Prec	Rec	Prec	Rec
TCONVS2S	0.67	0.80	0.75	0.83
PTGEN	0.73	0.86	0.73	0.90
Reference	0.49	0.63	0.48	0.67

Table 3: Coefficient of variation (lower is better) for evaluating summaries against documents with and without highlights.

from 3 different participants for each model summary. Table 2 and 3 presents our results.

Both the highlight-based and non-highlight based assessment of summaries agree on the ranking among TCONVS2S, PTGEN and Reference. Perhaps unsurprisingly human-authored summaries were considered best, whereas, TCONVS2S was ranked 2nd, followed by PTGEN. However, the performance difference in TCONVS2S and PTGEN is greatly amplified when they are evaluated against document with highlights (6.48 and 5.54 Precision and Recall points) compared to when evaluated against the original documents (3.98 and 1.83 Precision and Recall points). The performance difference is lowest when they are evaluated against the reference summary (2.51 and -1.79 Precision and Recall points). The superiority of TCONVS2S is expected; TCONVS2S is better than PTGEN for recognizing pertinent content and generating informative summaries due to its ability to represent high-level document knowledge in terms of topics and long-range dependencies (Narayan et al., 2018b).

We further measured the agreement among the judges using the coefficient of variation (Everitt, 2006) from the aggregated results. It is defined as the ratio between the sample standard deviation and sample mean. It is a scale-free metric, i.e. its results are comparable across measurements of different magnitude. Since, our sample size is small (3 judgements per summary), we use the unbiased version (Sokal and Rohlf, 1995) as $cv = (1 + \frac{1}{4n}) \frac{\sigma}{\bar{x}}$, where σ is the standard deviation,

Model	Fluency	Clarity
TCONVS2S	69.51	67.19
PTGEN	55.24	52.49
Reference	77.03	75.83

Table 4: Mean "Fluency" and "Clarity" scores for TCONVS2S , PTGEN and Reference summaries. All the ratings were collected on a 1-100 Likert scale.

Model	Unigram		Bigram	
	Prec	Rec	Prec	Rec
ROUGE (Original document)				
TCONVS2S	77.17	4.20	26.12	1.21
PTGEN	77.09	4.99	28.75	1.64
Reference	73.65	4.42	22.42	1.17
HROUGE (Highlights from the document)				
TCONVS2S	7.94	5.42	3.30	2.11
PTGEN	7.90	6.46	3.37	2.64
Reference	7.31	5.73	2.39	1.84

Table 5: HROUGE-1 (unigram) and HROUGE-2 (bigram) precision, and recall scores for TCONVS2S , PTGEN and Reference summaries.

n is the number of sample, and \bar{x} is the mean.

We found that the highlight-based assessment in general has lower variation among judges than the non-highlight based or reference-based assessment. The assessment of TCONVS2S summaries achieves 0.67 and 0.80 of Precision and Recall cv points which are 0.08 and 0.03 points below when they are assessed against documents with no highlights, respectively. We see a similar pattern in Recall on the assessment of PTGEN summaries. Our results demonstrate that the highlight-based assessment of abstractive systems improve agreement among judges compared to when they are assessed against the documents without highlights or the reference summaries. The assessment of human-authored summaries does not seem to follow this trend, we report a mixed results (0.49 vs 0.48 for precision and 0.63 vs 0.67 for recall) when they are evaluated with and without the highlights.

5.3 Clarity and Fluency Evaluation

Table 4 shows the results of our fluency and clarity evaluations. Similar to our highlight-based content evaluation, human-authored summaries were considered best, whereas TCONVS2S was ranked 2nd followed by PTGEN, on both measures. The Pearson correlation between fluency and clarity evaluation is 0.68 which shows a weak correlation; it confirms our hypothesis that the "clarity" captures different aspects from "fluency" and they should not be combined as it is commonly done.

5.4 Highlight-based ROUGE Evaluation

Table 5 presents our HROUGE results assessing TCONVS2S , PTGEN and Reference summaries with the highlights. To compare, we also report ROUGE results assessing these summaries against the original document without highlights. In the latter case, HROUGE becomes the standard ROUGE metric with $\beta_g^n = 1$ for all n -grams g .

Both ROUGE and HROUGE favour method of copying content from the original document and penalizes abstractive methods, thus it is not surprising that PTGEN is superior to TCONVS2S, as the former has an explicit copy mechanism. The fact that PTGEN is better in terms of HROUGE is also an evidence that the copying done by PTGEN selects salient content, thus confirming that the copying mechanism works as intended. When comparing the reference summaries against the original documents, both ROUGE and HROUGE confirm that the reference summaries are rather abstractive as reported by Narayan et al. (2018b), and they in fact score below the system summaries. Recall scores are very low in all cases which is expected, since the 10 highlights obtained per document or the documents themselves, taken together, are much longer than any of the summaries.

6 Qualitative Analysis

ARTICLE:
The yellow warning will remain in force until 11:00 on Sunday. Forecasters said showers accompanied by widespread sub-zero temperatures would see ice form on many untreated roads. Some snow is expected even at low levels in northern Scotland and other areas could see 2-3cm fall on higher ground. A Met office forecaster said: "Over northern Scotland showers will fall as snow to low levels. " Elsewhere within the warning area these showers will be turning increasingly wintry, with the main snow level down to between 100 and 200m by the end of the night. " Locally 2 or 3 cm of snow is possible above 200m . "
SUMMARY:
Reference: a weather warning has been issued for most parts of scotland , with drivers urged to be aware of a risk of ice and snow .
TCONVS2S: the met office has issued a yellow `` be aware `` warning for snow in parts of northern scotland .
PTGEN: forecasters have warned of severe thunderstorms across parts of scotland and scotland as snow is forecast to affect wintry weather .

Figure 3: Highlighted article, reference summary, and summaries generated by TCONVS2S and PTGEN. Words in red in the system summaries are highlighted in the article but do not appear in the reference.

Model	Summary Text	Fluency Clarity	
TCONVS2S	dick advocaat has resigned as sunderland manager <i>until the end of the season</i> .	92.80	44.33
PTGEN	sunderland have appointed <i>former sunderland boss</i> dick advocaat as manager <i>at the end of the season</i> to sign a <i>new deal</i> .	41.33	6.00

Table 6: TCONVS2S and PTGEN showing a disagreement between fluency and clarity scores. We italicized words that are not clear in the summaries.

HIGHRES eliminates reference bias. The example presented in Figure 3 demonstrates how our highlight-based evaluation eliminates reference bias in summarization evaluation. The summaries generated by TCONVS2S and PTGEN are able to capture the essence of the document, however, there are phrases in these summaries that do not occur in the reference summary. A reference-based evaluation would fail to give a reasonable score to these system summaries. The HIGHRES however, would enable the judges to better evaluate the summaries without any reference bias.

Fluency vs Clarity. Example in Table 6 shows disagreements between fluency and clarity scores for different summaries of the same article. From the example, we can see that the TCONVS2S summary is fluent but is not easily understood in the context of ‘the duration of resignation’, while the PTGEN summary has word duplication which lower the fluency and also lacking clarity due to several unclear words.

7 Conclusion and Future Work

In this paper we introduced the HIGHLIGHT-based Reference-less Evaluation Summarization (HIGHRES) framework for manual evaluation. The proposed framework avoids reference bias and provides absolute instead of ranked evaluation of the systems. Our experiments show that HIGHRES lowers the variability of the judges’ content assessment, while helping expose the differences between systems. We also showed that by evaluating clarity we are able to capture a different dimension of summarization quality that is not captured by the commonly used fluency. We believe that our highlight-based evaluation is an ideal setup of abstractive summarization for three reasons: (i) highlights can be crowd sourced effectively without expert annotations, (ii) it avoids

reference bias and (iii) it is not limited by n-gram overlap. In future work, we would like to extend our framework to other variants of summarization e.g. multi-document. Also, we will explore ways of automating parts of the process, e.g. the highlight annotation. Finally, the highlights could also be used as training signal, as it offers content saliency information at a finer level than the single reference typically used.

Acknowledgments

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Supplementary Material

1 Highest and lowest highlight annotation agreement articles

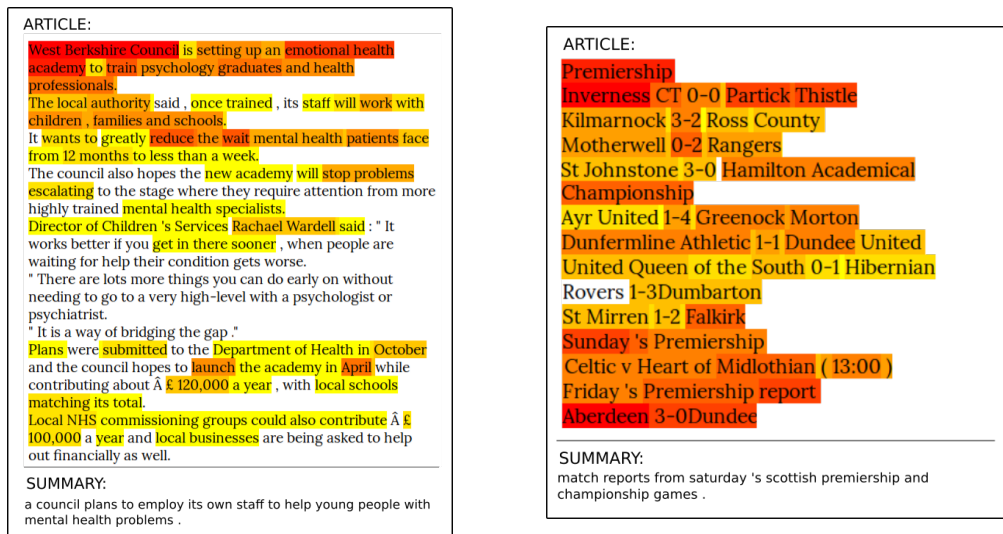


Figure 1: Highlight annotation for the documents with the highest (left) and lowest (right) agreement. We also show their reference summaries at the bottom.

2 Overview of Manual Evaluations

Systems	No Manual Eval	Pyramid QA	Correctness	Fluency	Clarity	Recall	Precision	Absolute	Relative	With Reference	With Document	With Ref. & Doc.
See et al. (2017)	✓											
Lin et al. (2018)	✓											
Cohan et al. (2018)	✓											
Liao et al. (2018)	✓											
Kedzie et al. (2018)	✓											
Amplayo et al. (2018)	✓											
Jadhav and Rajan (2018)	✓											
Li et al. (2018a)	✓											
Pasunuru and Bansal (2018)	✓											
Cao et al. (2018)	✓											
Sakaue et al. (2018)	✓											
Celikyilmaz et al. (2018)						✓	✓	✓	✓	✓	✓	
Chen and Bansal (2018)			✓			✓	✓	✓	✓			✓
Guo et al. (2018)				✓			✓		✓			✓
Hardy and Vlachos (2018)				✓				✓				
Hsu et al. (2018)				✓		✓	✓	✓			✓	
Krishna and Srinivasan (2018)						✓			✓		✓	
Kryściński et al. (2018)				✓		✓		✓			✓	
Li et al. (2018b)			✓					✓				
Narayan et al. (2018a)				✓					✓		✓	
Narayan et al. (2018b)		✓		✓		✓		✓	✓	✓	✓	
Narayan et al. (2018c)		✓		✓		✓		✓	✓	✓	✓	
Peyrard and Gurevych (2018)						✓	✓	✓		✓		
ShafieiBavani et al. (2018)		✓										
Song et al. (2018)			✓	✓		✓		✓			✓	
Yang et al. (2017)						✓			✓	✓		
HIGHRES (ours)				✓	✓	✓	✓	✓			✓	

Table 1: Overview of manual evaluations conducted in recent summarization systems. We categorize them in four dimensions: the first columns presents papers that do not report on human evaluation; the second column identifies matrices used for evaluating content (“Pyramid”, “QA”, “Correctness”, “Recall” and “Precision”) and quality (“Clarity”, “Fluency”) of summaries; the third column focuses if the system ranking reported by humans on content evaluation were “Absolute” or “Relative”; and finally, the fourth column evaluates if summaries were evaluated against the input document (“With Document”), the reference summary (“With Reference”) or both (“With Ref. & Doc.”).

3 HighRES User Interface Screenshots

Instructions

Your task is to **select important phrases** from the document by highlighting them.

Select phrases that are the most informative, use the **SW1H principle** (who, what, when, where, why and how) to determine the informativeness of a phrase.

The maximum combined length of all highlighted phrases is **30 words**. If you feel that 30 words is not enough to highlight all important information, then highlight only the most important parts that fit within this limit.

To highlight, use your mouse to select phrases from the document, and click on the pen icon.

To delete a group of highlights, right click on it and confirm.

A 24-hour walkout by members of the Rail , Maritime and Transport (RMT) union , in protest at the introduction of driver-only trains , ended at 11:00 BST on Wednesday.

Southern warned passengers to expect " difficult and frustrating " journeys throughout the day.

Two further strikes have been announced for 10 May and 12 May.

Latest updates here The RMT confirmed it would attend talks with Southern " over the guards jobs and safety dispute " on Friday.

Dyan Crowther , chief operating officer for Southern owner Govia Thameslink Railway , told BBC Sussex : " We are very pleased to hear that and we look forward to meeting the RMT " .

Southern said some routes were again suspended or reduced with 700 fewer services across Sussex and east Surrey.

Ms Crowther said the timetable would not return to normal until Thursday as they needed to get rolling stock and staff into the right position.

Paul Barker , a commuter from Rye , normally catches a Southern train to Ashford then a high-speed service to St Pancras.

He said he worked from home on Tuesday but went to Robertsbridge on Wednesday to catch a Southeastern service to London.

He said : " It was standing room only from Frant , but you can not take two days off work " .

RMT general secretary Mick Cash said : " This dispute is about safety.

The company , with an eye on ever-fatter profits , is prepared to axe the guards on some of the most overcrowded and potentially-dangerous services . " The company said there would be no job or pay cuts but the planned changes would make conductors more visible while drivers would operate doors.

It accused the RMT of " scaremongering " and said " driver-only operation is a safe , proven way of working " which had been used " on 40 % of trains across the Southern network for 25 years " .

Click to submit

Summary

Words left
18 words.

Highlighted Phrases:

1: Southern warned passengers to expect " difficult and frustrating " journeys

2: Two

Figure 2: The UI for highlight annotation. Judges are given an article and asked to highlight words or phrases that are important in the article.

Please Answer the Following Question

Is the statement below is True or False?

There are five more strikes that has been announced.

☒ True ☐ False

Submit

Figure 3: The sanity checking question at the end of the annotation task.

Instructions & Controls

Your task is to assess the quality of the summary based on the document.

Labour MP for Bassetlaw , John Mann , a Leave campaigner , said people voted to leave because of immigration , zero-hour contracts and job prospects and said a " divide in Britain " had been exposed.

Mansfield voted most strongly to leave , with 70.9 % backing Brexit.

Rushcliffe , which includes the towns of West Bridgford and Bingham , was the only area to vote for Remain.

It saw the East Midland 's highest turnout.

Meanwhile , the turnout in Nottingham was the fifth lowest in the UK at 61.8 %.

Leave won by a tiny margin of just over 2,000 votes in the city.

Mr Mann said his party was " somewhat out of touch ".

" With the middle classes largely voting remain because they see it as benefiting them and the working classes largely voting to leave because it dis-benefits them - that 's the divide in Britain , " he said.

Latest reaction and updates from Nottinghamshire Like large parts of England , Nottinghamshire overwhelmingly voted to leave the European Union.

The margin of victory in Bassetlaw , Ashfield and Mansfield was huge , with less than a third of people voting remain.

Arguably the biggest surprise came in Nottingham , which narrowly backed Brexit.

Affluent Rushcliffe was the only area to vote Remain.

Overall Nottinghamshire voted 57.9 % for Leave and 42.1 % for Remain.

Conservative Anna Soubry , the MP for Broxtowe and a Remain campaigner , tweeted it was " a dreadful decision ".

" People like me were told you 're scaremongering , we do n't want to listen to the experts , " she said.

" All that has been unfortunately proved to be accurate.

We have made a very , very , very bad mistake ." Labour MP for Nottingham North , Graham Allen , said David Cameron had " gambled with Britain 's future " by calling for a referendum , saying people voted to leave " in protest " at the current government.

Turnout was 81.5 % in Rushcliffe - the highest in the East Midlands and the only council area to vote Remain.

The vote was close elsewhere , including in Nottingham , where the split was 50.8 % Leave , 49.2 % Remain.

Alice , a caller to BBC Radio Nottingham from the Carrington area of the city , said she felt " frightened of the future ".

" It potentially gives a mandate for a lot of prejudice against people who have immigrated here , whether from the EU or elsewhere , " she said.

Assessment

Assess the following summary.

labour has voted to leave the european union after voters voted to leave the eu .

How strongly agree are you on the following statements?

❶ All important information is present in the summary

Strongly disagree 50 Strongly agree

❷ Only important information is in the summary.

Strongly disagree 50 Strongly agree

Click to submit

Figure 4: The UI for content evaluation without highlight. At the right of the page judges give the recall and precision assessment by sliding the scroller from 1 to 100 based on the given summary quality.

Reference Sentence

many older people living in care homes have an " unacceptable quality of life " and quickly become institutionalised , says a watchdog .

Assessment

Assess the following summary.

care homes in care homes in wales have been rated inadequate , a report has found .

How strongly agree are you on the following statements?

Hover the mouse on top of the 1 to see more information.

1 All important information is present in the summary

Strongly disagree 50 Strongly agree

1 Only important information is in the summary.

Strongly disagree 50 Strongly agree

Click to submit.

Figure 5: The UI for content evaluation using reference summary as comparison. At the right of the page judges give the recall and precision assessment by sliding the scroller from 1 to 100 based on the given summary quality.

Assess the following summary.

the former head of the world 's biggest technology companies , judges hart , has been awarded a knighthood in the new year honours list .

How strongly agree are you on the following statements?

Hover the mouse on top of the 1 to see more information.

1 The summary is fluent.

Strongly disagree 50 Strongly agree

Prev 8/8 Next Finish

Figure 6: The UI for fluency evaluation. Judges are given a number of summaries which can be switched by pressing the 'Prev' or 'Next' button. To give assessment, there is a scroller from 1 to 100.

Assess the following summary.

dick advocaat has resigned as sunderland manager until the end of the season .

How strongly agree are you on the following statements?

Hover the mouse on top of the 1 to see more information.

1 The summary is a clear.

Strongly disagree

50

Strongly agree

Prev

8/8

Next

Finish

Figure 7: The UI for clarity evaluation. Judges are given a number of summaries which can be switched by pressing the ‘Prev’ or ‘Next’ button. To give assessment, there is a scroller from 1 to 100.