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The Healing Power of Poison: Helpful Non-relevant Documents in Feedback

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ABSTRACT

The use of feedback information is an effective approach to address the vocabulary gap between a user’s query and the relevant documents. It has been shown that some relevant documents act like “poison pills,” i.e. they hurt the performance of feedback systems despite the fact that they are relevant. In this paper, we study the positive counterpart of this by investigating the helpfulness of non-relevant documents in feedback. In general, we find that although documents that are explicitly judged as non-relevant are normally assumed to be poisonous for feedback systems, sometimes considering high-scored non-relevant documents as a positive feedback helps to improve the performance of retrieval. In our experimental data, we observe a considerable fraction of non-relevant documents in higher ranked positions of the initial retrieval run, for most of the topics. Hence, by ignoring the potential value of non-relevant documents, we may loose a lot of useful information.

We investigate the potential contribution of non-relevant documents using existing state-of-the-art feedback methods. Our main findings are the following. First, we find that some of the non-relevant documents are exclusively helpful, they improve retrieval on their own, and others are complementary helpful, they lead to further improvement when added to a set of relevant documents. Second, we discover that, on average, exclusively helpful non-relevant documents have a higher contribution to the performance improvement, compared to the complementary ones. Third, we show that non-relevant documents in topics with poor average precision in the initial retrieval are more likely to help in the feedback.

Keywords: Relevance Feedback, Helpful Non-relevant Documents

1. INTRODUCTION

Often, the only difference between a medicine and a poison is the dose. Some substances are extremely toxic, and therefore, are primarily known as a poison. Yet, even poisons can have medicinal value.

Paracelsus, Father of Toxicology

Query expansion based on feedback information is one of the classic approaches for improving the performance of information retrieval systems, especially when the user information need are complex to express precisely in a few keywords. True Relevance Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

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Table 1: Number of helpful non-relevant documents in different rank levels in the initial run.

<table>
<thead>
<tr>
<th>level</th>
<th>Robust</th>
<th></th>
<th>WT10G</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NR</td>
<td>BHNr</td>
<td>CHNR</td>
<td>NR</td>
</tr>
<tr>
<td>5</td>
<td>641</td>
<td>55 (9.6)</td>
<td>106 (5.6)</td>
<td>314</td>
</tr>
<tr>
<td>10</td>
<td>1404</td>
<td>82 (5.5)</td>
<td>205 (6.5)</td>
<td>671</td>
</tr>
<tr>
<td>15</td>
<td>2212</td>
<td>86 (5.9)</td>
<td>219 (9.9)</td>
<td>1050</td>
</tr>
<tr>
<td>20</td>
<td>3083</td>
<td>91 (2.9)</td>
<td>232 (7.5)</td>
<td>1423</td>
</tr>
<tr>
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<td>112 (1.3)</td>
<td>241 (9.2)</td>
<td>3862</td>
</tr>
<tr>
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<td>18630</td>
<td>124 (0.7)</td>
<td>250 (9.1)</td>
<td>14040</td>
</tr>
<tr>
<td>500</td>
<td>66269</td>
<td>129 (0.2)</td>
<td>257 (0.4)</td>
<td>30827</td>
</tr>
</tbody>
</table>

Figure 2: Percentage of topics with different types of non-relevant documents in different rank positions.

Figure 3: Intra and inter similarity of relevant (R), SNR, BHNr, and CHNR documents.

We use the Robust04 with 528,155 newswire documents and 249 topics, as well as WT10G with 1,692,096 web documents and 99 topics as the test collections, which are different in terms of both size and genre of documents. We use the KL-Divergence model, with Dirichlet smoothing as the retrieval model in all of the experiments. We employ three state-of-the-art feedback methods, relevance model (RM3) [1], MEDMM [11], and SWLM [2, 3]. It is important to note that we investigate only documents that are explicitly judged as non-relevant, and ignore unjudged documents.

2. HELPFUL NON-RELEVANT DOCUMENTS

In this section, we address our first research question: “How can a non-relevant document help to improve retrieval performance?” Typically, it is expected that using a non-relevant document as positive feedback would cause a decrease in the average precision (AP). However, we show that some non-relevant documents not only do not hurt the feedback performance but they will even improve it.

Some hypothesis may be explanatory to this kind of documents. The first thing that comes to mind is that this is the effect of judge-noises and these documents are relevant but they have been misjudged. The second argument is that these documents are generally relevant to the topic but have no new valuable information to satisfy the user and because of using binary relevance judgments, they are annotated as non-relevant. In this case, they might contain terms that are helpful for query expansion. There is a discussion in linguistics that every utterance has two basic parts, theme, which indicates the topic of discourse, and rheme, which gives new information about the theme. In the retrieval problem, in rather crude terms, we may say that the theme of a document states what it is about, and the rheme of a document expresses what the searcher wishes to find in it [2]. So, for the searcher, relevance is a function of both theme and rheme of the document based on her current interests and his personal state of knowledge, while for the feedback method relevance is a function of the place of the document in the current state of knowledge as a whole. Thus, the mere annotation of a document as non-relevant for a topic does not imply that the document is not useful as positive feedback for that topic.

2.1 Bridge HNR

To understand the properties and behavior of HnR documents, we are attempting to extract the most explicit instances of HnR in our test collection and study their characteristics. To this end, for each of the feedback methods we use a single non-relevant document appearing in top-k retrieved documents per topic as the only feedback document and keep the track of change in AP of the corresponding topic. If the document makes the AP increase in all the systems, we mark that document as a HnR document.

We looked into several instances and found that regardless of the judgement noise, most of the times a non-relevant document improves the performance in single document feedback in two different situations: First, when the topic is a specific topic and the...
HNR document is a broadly topical document, which does not address directly the topic in a particular way, but some general frequent words in the language usage of the document help to retrieve more specific documents in the next feedback run. For example, in Robust04 dataset, topic 311 is “Industrial Espionage”, and one of the HNR documents is about “counter-espionage services for combating organised crime, terrorism and foreign operations”, and expanding query with generally related terms like terrorism, foreign, etc. boost the score of some relevant documents in the feedback run. Second, when the topic is a topic which the user is able to articulate in different ways and the helpful non-relevant document does not address the user information need, but some of its frequent words express the topic in other ways. For instance, in Robust04 dataset, topic 348 is “creativity”, which based on the description of the topic, relevant documents are supposed to be about the definition of creativity, and one of the HNR documents is about “the founder of a company in Singapore, named Creative Technology”, which contains terms like “original thinkers”, “smart”, “innovation”, and these terms are related to the main concept of creativity. In both of these cases, the HNR document is not directly related to the topic, but it plays the role of a bridge to non-retrieved relevant documents. We refer to these documents as Bridge Helpful Non-relevant (BHNR) documents.

2.2 Complementary HNR

In a second experiment, we give one more chance to the remaining non-relevant documents to be helpful. To do this, for each topic, we check if adding the non-relevant document to the true relevance feedback set will further improve its performance. Thus, we examine the possibility of each individual non-relevant document to be helpful when it is used along with a set of relevant documents. We mark the documents that have a positive effect on the AP of the corresponding topic, in all the systems as a HNR document.

We explored different cases where a non-relevant document helps together with a set of relevant documents and discovered that this happens mostly in the situations where the HNR document is a multi-topic document, and technically it is partially relevant. This document is not able to be helpful in single-document feedback since its non-relevant part causes topic drift [6, 12]. However, together with other relevant documents, not only the effect of its non-relevant part is neutralised and compensated by the relevant documents, but its relevant part even reinforces the feedback models. We refer to these documents as Complementary Helpful Non-relevant (CHNR) documents. We examined the BHNR documents in our second experiment and observed that all of them are CHNR as well. So, we exclude them from CHNR documents to better analyse properties of each type. In Table[1], the rate of BHNR and CHNR documents are listed in different rank levels of the initial run in two datasets. As it is expected, in both datasets and in both types, HNR documents occur in a higher percentage in the early rankings. Moreover, an inspection of the various depth levels shows that from all HNR documents in top 500, a high percentage of them (60%-75%) take place in top-10. This might be one of the reasons that most of the pseudo relevance feedback methods work well with ten feedback documents [9]. We will restrict our analysis on the helpfulness of non-relevant documents to this level, i.e. up to rank ten. We also looked into the agreement of the three feedback methods in our experiments and observed that they behave quite differently. So, as a pragmatic choice, we study only the clear cases where all the methods agree on their helpfulness.

As it is pointed out in the introduction, we think that every high-scored retrieved document, either judged as relevant or non-relevant, can help feedback systems improve the performance. However, in this paper, we are not able to reveal the healing power of some of them, maybe because of the design of our experiments or due to the shortcoming of the existing feedback methods. Hence, we do not call them “bad” relevant document, and instead, we call them, Stubborn Non-relevant (SNR) documents. Figure[2] shows how likely a non-relevant document can be helpful in different top-10 rank positions. As expected, the percentages of the topics with HNR documents are higher in the higher ranks and generally, non-relevant documents are more likely to help along with a set of relevant documents, as CHNR, than individually as BHNR.

In order to understand the relation between HNR, SNR, and relevant documents, for each type of HNR documents, we select topics with at least two HNR, two SNR, and two relevant documents in their top ten results and calculate the intra and inter similarity of these groups of documents based on the average similarity of all document pairs, using JS-Divergence of their smoothed language models. Figure[3] shows the intra and inter similarity of relevant, SNR, BHNR, and CHNR documents in two datasets. As it is expected, in both datasets, the similarity of BHNR to the relevant documents and CHNR to the relevant documents is relatively higher than the similarity of SNR documents to the relevant documents. However, the intra similarity of BHNR documents is higher than CHNR documents. This observation is in accordance with the assumption that the BHNR documents are related to the topic (hence similar to the relevant documents) in general but they do not have the particular information which satisfies the searcher to be annotated as relevant. Also, CHNR documents are mostly multi-topic documents that have a part related to the query, but their non-relevant parts could be quite diverse, which leads to a low intra similarity.

3. IMPACT OF HNR DOCUMENTS

We now investigate our second research question: “How large is the contribution of helpful non-relevant feedback documents?” In order to evaluate the impact of HNR documents on the performance of feedback, we calculate the average of change of AP they make over all the employed feedback systems. For BHNR documents, we consider the amount of AP change compared to the initial run, and for CHNR, we consider the AP change compared to the feedback run without their presence in the feedback set. Figure[4] depicts the distribution of BHNR and CHNR documents based on the amount
of highly ranked non-relevant documents for improving further re-

performance individually as a BH document helps as a CH document.

in accordance with the observations from Figure 7, where the percent-

number of S is easier to improve it, while when the performance of the baseline

of the initial retrieved results?” In order to understand the relation

of the initial retrieved results. We designed some experiments based on the existing state-of-the-art feedback methods
to assess the possibility of helpfulness of non-relevant documents.

We found that some of the non-relevant documents can be helpful
eclusively, and some others may help when they are employed as a complement to a set of relevant documents. We also dis-
covered that in average compared to complementary ones, exclusively
helpful non-relevant documents have a higher contribution to the

improvement in performance. In addition, we showed that the

non-relevant documents in topics with poor average precision in the

initial retrieval are more likely to help in the feedback.

This research is a primary step and further analysis is necessary
to understand the nature of helpful non-relevant documents and how
we can change feedback methods to be able to better take advantage
of them. Also, as a direction from which this research is extendable,
we are going to build a classifier to characterise the helpfulness of
non-relevant documents based on the existing feedback methods.

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