Significance of Sentence Ordering in Multi Document Summarization

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ABSTRACT
Multi-document summarization represents the information in a concise and comprehensive manner. In this paper we discuss the significance of ordering of sentences in multi-document summarization. We show experimental results on DUC2002 dataset. These results show the ordering of summaries before and, improvement in this, after applying sentence ordering. For this purpose we used a term frequency based summarizer \cite{9} and a centroid based summarizer \cite{4} for multi-document summarization and Kendall’s Tau co-efficient \cite{11} as performance evaluation metrics.

1. INTRODUCTION
With the rapid growth of information available on the World Wide Web the problem of information overload arises. Under these circumstances, it became very difficult for the user to find the document he actually needs. Moreover, most of the users are reluctant to make the cumbersome effort of going through each of these documents. Thus the technology of automatic text summarization is becoming essential to deal with the problem of information overload. Text summarization is the process of filtering the most important information from a single document or from a set of documents to produce a short and information rich summary.

Most multi-document summarization systems are based on the information extraction method, which extracts the most important sentences in source documents and include them in to the summary document \cite{1}. So for such system it is very much important to provide a coherent ordering of the sentences extracted from different source documents in order to make the summary meaningful. Sentence ordering, which affects coherence and readability, is of particular concern for multi-document summarization, where different source articles contribute sentences to a summary. Here, we use chronological approach for improving the ordering of sentences. We apply sentence ordering on the summaries generated by a term frequency based summarizer \cite{9} and mead summarizer \cite{13} and evaluate against summaries provided in DUC2002 dataset \cite{12}. The block diagram is shown in figure 1.

2. RELATED WORK
The first systematic research on sentence ordering was done by Barzilay, et al. \cite{2} they provided a corpus based approach to study ordering and conducted experiments which show that sentence ordering significantly affects the reader’s comprehension. They also evaluated two ordering strategies: majority ordering which orders sentences by their most frequent orders across input documents and chronological ordering which orders sentences by their original article’s publishing time. They then introduced an augmented chronological ordering with topical relatedness information that achieves the best results.

Bollegala, Okazaki and Ishizuka \cite{3} provide a novel supervised learning framework to integrate different criteria. They also propose two new criteria precedence and succession developed from their previous work. A fundamental assumption for the precedence criteria is that each sentence in newspaper articles is written on the basis that pre-suppositional information should be transferred to the reader before the sentence is interpreted. The opposite assumption holds for the succession criteria. They define a precedence function between two segments (a sequence of ordered sentences) on different criteria and formulate the criteria integration task as a binary classification problem and employ a Support Vector Machine (SVM) as the classifier. After the relations between two textual segments are learned, they then repeatedly concatenate them into one segment until the overall segment with all sentences is arranged. Precedence and succession are interesting criteria, but as we use a human written summary, such information is not available.

Barzilay and Lapata focus on the evaluation of sentence order quality rather than generating a sentence order directly. Inspired by Centering Theory \cite{4}, Barzilay and Lapata \cite{5} introduce an entity-based representation of discourse and treat coherence assessment as a ranking problem based on different

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Block Diagram for Multi Document Summarization with Sentence Ordering}
\end{figure}
discourse representations. A discourse entity is a class of coreferent noun phrases. They use a grid to represent a set of entity transition sequences that reflect distributional, syntactic, and referential information about discourse entities.

An unsupervised probabilistic model has been suggested by Lapata [6] for text structuring that learns ordering constraints from sentences represented by a set of lexical and structural features.

Barzilay and Lee [7] have proposed domain-specific content models to represent topics and topic transitions for sentence ordering. They learn the content structure directly from unannotated texts via analysis of word distribution patterns based on the idea that “various types of [word] recurrence patterns seem to characterize various types of discourse” [8]. The content models are Hidden Markov Models (HMMs) where in states correspond to types of information characteristic to the domain of interest, and state transitions capture possible information-presentation orderings within that domain.

3. TERM FREQUENCY BASED SUMMARIZER

In term frequency based summarization process, the first stage inputs the set of source documents that are clustered around the same topic or subject or event. The next stage computes the term frequency. The final stage ranks the sentences based on the terms they contained and their term score, and finally the high ranking sentences are selected for inclusion in the summary.

We can see this in a stepwise manner

Step 1: Input the set of documents
Step 2: Perform part of speech tagging
Step 3: Compute the term frequency and prepare the feature list
Step 4: Prepare the term frequency matrix consisting the frequency value for each word
Step 5: Assign the scores to the sentences based on the term frequency score
Step 6: Select the sentences with high scores to include in the summary

One formal method to capture this phenomenon would model the appearance of words in the summary under a multinomial distribution. That is, for each word w in the input vocabulary, we associate a probability p(w) for it to be emitted into a summary. The overall probability of the summary then is

\[
\frac{N!}{n_1!...n_r!} p(w_1)^{n_1} ... (w_n)^{n_r} \cdots (1)
\]

Where N is the number of words in the summary, n_1 + ... + n_r = N and for each i, n_i is the number of times word w_i appears in the summary and p(w_i) is the probability that w_i appears in the summary.

4. MEAD SUMMARIZEr

The centroid-based method is one of the most popular extractive summarization methods. MEAD is an implementation of the centroid-based method [9]. Radev et al. [10] described an extractive multi-document summarizer (MEAD) which chooses a subset of sentences from the original documents based on the centroid of the input documents. For each sentence in a cluster of related documents, MEAD computes three features and uses a linear combination of the three to determine the most important sentences. The three features used are centroid score, position, and overlap with first sentence (or the title).

The centroid score C_i is a measure of the centrality of a sentence to the overall topic of a cluster. The position score P_i which decreases linearly as sentence gets farther from the beginning of the document, and the overlap with first sentence score F_i which is the inner product of the tf-idf weighted vector representations of a given sentence and the first sentence (or title) of the document. All three features are normalized (0-1) and the overall score for a sentence Si is calculated as

\[
W(S_i) = W_c * C_i + W_p * P_i + W_o * F_i, \cdots (2)
\]

Where W_c, W_p, and W_o are the individual weight age given to each type of features respectively. MEAD discards sentences that are too similar to other sentences. Any sentence that is not discarded due to high similarity and which gets a high score is included in the summary.

5. SENTENCE ORDERING

Ordering of sentences in multi-document summarization is important and critical task. The problem of organizing information for multi-document summarization so that the generated summary is coherent has received relatively little attention. While sentence ordering for single-document summarization can be determined from the ordering of sentences in the input article, this is not the case for multi-document summarization where summary sentences may be drawn from different input articles.

For this purpose we used Chronological ordering approach. Multi-document summarization of news typically deals with articles published on different dates, and articles themselves cover events occurring over a wide range in time. Using chronological order in the summary to describe the main events helps the user understand what has happened. For instance, in a terrorist attack story, the theme conveying the attack itself will have a date previous to the date of the theme describing a trial following the attack [10].

Chronology criterion reflects the chronological ordering (Lin and Hovy, 2001; McKeown et al., 1999), which arranges sentences in a chronological order of the publication date. We define the association strength of arranging segments B after A measured by a chronology criterion f_chro (A > B) in the following formula,
Significance of Sentence Ordering in Multi Document Summarization

\[
f_{\text{dup}}(A > B) = \begin{cases} 
1 & [T(a_m) < T(b_1)] \\
1 & [D(a_m) = D(b_1)] \land [N(a_m) < N(b_1)] \\
0.5 & [T(a_m) = T(b_1)] \land [D(a_m) \neq D(b_1)] \\
0 & \text{otherwise}
\end{cases}
\]

(3)

See Figure 2 Summary Before Sentence Ordering
Here, \(a_m\) represents the last sentence in segment \(A\); \(b_1\) represents the first sentence in segment \(B\); \(T(s)\) is the publication date of the sentence \(s\); \(D(s)\) is the unique identifier of the document to which sentence \(s\) belongs; and \(N(s)\) denotes the line number of sentence \(s\) in the original document. The chronological order of arranging segment \(B\) after \(A\) is determined by the comparison between the last sentence in the segment \(A\) and the first sentence in the segment \(B\). The chronology criterion assesses the appropriateness of arranging segment \(B\) after \(A\) if: sentence \(a_m\) is published earlier than \(b_1\); or sentence \(a_m\) appears before \(b_1\) in the same article. If sentence \(a_m\) and \(b_1\) are published on the same day but appear in different articles, the criterion assumes the order to be undefined. If none of the above conditions are satisfied, the criterion estimates that segment \(B\) will precede \(A\) [3].

See Figure 2 Summary Before Sentence Ordering

Figure 2 shows the summary before sentence ordering and figure 3 shows the summary after sentence ordering. Here the events are arranged as they were published so the information is provided in chronological manner. This approach is suitable for our work as we are using news summaries as input.

See Figure 3 Summary after Sentence Ordering

### 6. RESULTS

We used DUC 2002, one of the document collections provided by the Document Understanding Conference (DUC) [12]. DUC is established and funded by DARPA (Defense Advanced Research Project Agency) and run by independent evaluator NIST (National Institute of Standards and Technology). DUC 2002 data consists of 300 newspaper articles on 30 different topics, collected from Financial Times, Wall Street Journal, Associated Press, and similar sources. This is a collection of newswire articles; comprised of 59 document clusters.

Here, we show the evaluation results for sentence ordering module on the DUC2002 data set for term frequency based summarizer and mead summarizer. For this purpose we calculated Kendall’s tau [11] before and after applying sentence ordering on the summaries generated by information extraction. Kendall’s \(\tau\) for the ordering task is evaluated as follows. Let \(Y = y_1 \ldots y_n\) be a set of items to be ranked. Let \(\pi\) and \(\sigma\) denote two distinct orderings of \(Y\), and \(S(\pi, \sigma)\) the minimum number of adjacent transpositions needed to bring \(\pi\) to \(\sigma\). Kendall’s \(\tau\) is defined as: \(\tau = 1 - \frac{2S(\pi, \sigma)}{N(N - 1)/2}\) where \(N\) is the number of objects (i.e., items) being ranked. Table 1 shows Kendall’s tau for the information extracted by the term frequency based summarizer before sentence ordering.

**Table 1:** Kendall’s Tau results for The Term Frequency Based Summarizer before Sentence Ordering

<table>
<thead>
<tr>
<th>Group Number</th>
<th>No. of Clusters per Group</th>
<th>Number of documents per cluster</th>
<th>Kendall’s tau</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
<td>0.33333</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>6</td>
<td>-0.11111</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>7</td>
<td>-0.5</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>8</td>
<td>0.33333</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>9</td>
<td>0.39688</td>
</tr>
<tr>
<td>6</td>
<td>22</td>
<td>10</td>
<td>0.6942</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>11</td>
<td>0.73333</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>12</td>
<td>0.19999</td>
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<td>9</td>
<td>1</td>
<td>13</td>
<td>-0.3333</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>14</td>
<td>0.5</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>15</td>
<td>0.3840</td>
</tr>
</tbody>
</table>

**Table 2:** shows Kendall’s tau coefficient value for the information extracted by the term frequency based summarizer after sentence ordering.

Figure 4 shows the comparison between the values of Kendall’s tau coefficient before and after sentence ordering for term frequency based summarizer. Here, we can see a remarkable improvement in the results as the Kendall’s tau varies up to 90% (approximately).

**Table 2:** Kendall’s Tau results for The Term Frequency Based Summarizer after Sentence Ordering

<table>
<thead>
<tr>
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<th>Number of documents per cluster</th>
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</tr>
</thead>
<tbody>
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<td>1</td>
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<td>5</td>
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<td>8</td>
<td>0.83333</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>9</td>
<td>0.59999</td>
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<td>0.77745</td>
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<td>11</td>
<td>0.88889</td>
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<td>14</td>
<td>0.5</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>15</td>
<td>0.77404</td>
</tr>
</tbody>
</table>

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Table 3 shows Kendall’s tau for the information extracted by the mead summarizer before sentence ordering.

Table 3: Kendall’s Tau Results for MEAD Summarizer before Sentence Ordering

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Number of Clusters per Group</th>
<th>Number of documents per cluster</th>
<th>Kendall’s tau</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>4</td>
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<td>7</td>
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</tr>
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<td>3</td>
<td>8</td>
<td>0.19999</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
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</tr>
<tr>
<td>10</td>
<td>2</td>
<td>14</td>
<td>0.325</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>15</td>
<td>0.25728</td>
</tr>
</tbody>
</table>

Table 4 shows Kendall’s tau coefficient for the information extracted by the mead summarizer after sentence ordering.

Table 4: Kendall’s Tau Results for MEAD after Sentence Ordering

Figure 5 shows the comparison between the values of Kendall’s tau before and after sentence ordering for mead summarizer. Here also, we can see a significant improvement in the results as the kendall’s tau varies up to 85% (approximately).

Table 5 shows average values of Kendall’s tau for both term frequency based summarizer and mead summarizer before and after sentence ordering.

Table 5: Comparison of Average Kendall’s Tau
**Significance of Sentence Ordering in Multi Document Summarization**

<table>
<thead>
<tr>
<th>Average Kendall’s Tau Values for</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term Frequency Based Summarizer</td>
<td>0.24</td>
<td>0.67</td>
</tr>
<tr>
<td>MEAD</td>
<td>0.13</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Figure 6 shows comparison between average tau before values of Kendall’s and after sentence ordering for both term frequency based summarizer and mead summarizer.

![Figure 6: Comparison of Average Kendall’s Tau](image)

The average value of kendall’s tau of summaries generated by term frequency based summarizer is improved up to 67% and that of summaries generated by mead summarizer is improved up to 63%

7. CONCLUSION

We applied Chronological sentence ordering on both the summarizers and used Kendall’s Tau co-efficient as performance evaluation metrics. We found experimentally that the ordering of both summarizers is improved up to a significant level (67%). This work can be extended by ordering the sentences by their content features. The work can also be extended to order the sentences on the basis of the sentence types. For this, we only need to find the types of sentences that are frequent in the documents of particular domain.

**REFERENCES**


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Border Clashes Continuing, Says Prime Minister

Despite the tension, officials from both sides said the incidents did not appear to be serious.

Pakistan, an Islamic state, denies the charge but says it will not back any movement for self-determination by Kashmiri people.

They say protesters received visas from the Korean, the Muslim holy book.

Abdullah's government resigned Friday to protect the appointment of Singh's nominee as the state's new governor and imposition of governor's rule which amounts to high

Parts of Kashmir region are claimed by both India and Pakistan.

U.N. observers are stationed on the truce line and the two sides occasionally trade gunfire.

India claims the fundamentalists get money and weapons from Pakistan.

The officials also blamed militants for a fire that broke out in a downtown shopping center.

Indian officials maintain that Kashmiri militants regularly cross over to Pakistan through the border and return by the same route after receiving arms training.

Security was strengthened across Srinagar after the incidents.

The Pakistan army: 1

New roadblocks were set up and more paramilitary troops were deployed on the streets, the official said.

A Pakistani official in Islamabad denied the accusations.

A Fluid 844 mile cease-fire line separates the Indian and Pakistani Kashmir.

Five were in critical condition in a hospital in Muzaffarabad, the capital of Pakistan-controlled Kashmir, he said, adding he knew of only one death.

Srinagar, the summer capital of Jammu and Kashmir, has been the center of the secessionist movement that has turned violent in recent years.

The soldier was shot in the leg Sunday at a ceasefire line, several miles from the village of Chaukoth, officials said on condition of anonymity.

They said there were no reports of casualties from today's firefight on the line, which divides Kashmir between Pakistan and India.

Prime Minister Benazir Bhutto on Thursday accused India of being "genocidal" in secession-minded Kashmir and of trying to start a war with Pakistan to deflect attention.

The leaders of both countries have tried to soothe tempers in the dispute and have said another war over the region is unlikely.

However, Pakistani forces have now sealed off the border area at Chaukoth, forbidding civilians from entering the area.

Meanwhile, the president of the Pakistan state of Kashmir said in an interview Saturday that Kashmiris there had begun smuggling arms across the border to Muslim guerrilla groups of young Moslem men at street corners, stopping passers-by and telling them to adjust their watches.

The decision was taken at the end of a day-long multistory meeting on Kashmir called by Prime Minister V.P. Heinze, Mahabed is one of 30 militant groups fighting for secession.

Family members and highly placed sources in the government of Jammu-Kashmir said no group has claimed responsibility for the abduction and no demands were issued.

The firing continued intermittently for more than an hour until the body was found at 5 p.m.

They left the region split into the Pakistan-held territory called Azad Kashmir, or free Kashmir, and the Indian-controlled Jammu-Kashmir state.

Official sources said Indian soldiers shot and killed 10 Muslim separatist Friday who were trying to slip into Pakistan-held territory of Kashmir.

Kashmiri militants had earlier campaigned for union with Pakistan, which claims Kashmir because of its predominant Moslem population, but now they demand independence.

The cell was also targeted for the Students Liberation Front, a branch of the Jammu and Kashmir Liberation Front fighting for autonomy in the predominantly Moslem state.

Police said the border violence took place in Upward district, where at least 20 separatists tried to sneak into neighboring Pakistan to receive military training and buy in India and Pakistan have fought two wars over the region since 1947, when both nations won independence from Britain.

The deaths raise to 630 the number of people killed since security forces began a crackdown on the Moslem movement on Jan.

The Kashmir valley, most of which falls in the Indian state of Jammu and Kashmir, is predominantly Moslem.

India has accused Pakistan of arming and training the militants, a charge Pakistan has denied.

About 65 percent of Jammu and Kashmir's 6 million people are Moslem, making it India's only Moslem majority state.

Indian officials maintian that Kashmiri militants regularly cross over to Pakistan through the porous border and return by the same route after receiving arms training in Pakistan.

The Kashmir officials said the fighting erupted when the militants fired at Indian border guards after crossing over from Pakistan.

At least five more Moslem separatists were killed in three separate incidents across Kashmir today.

Nationwide, Moslems make up 12 percent of India's 800 million people.

Figure 2 Summary Before Sentence Ordering
Figure 3 Summary after Sentence Ordering

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