Assembly of Topic Extraction Modules in SUMMARIST

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Abstract

Over the past two years we have been developing the text summarization system SUMMARIST. In this paper, we describe the current status of SUMMARIST and its use in TIPSTER Phase III text summarization research.

Introduction

As more and more online information services become available, there is increasing interest in how to digest this information and make good use of it. Because the amount of data is so overwhelming, it is simply not possible to rely solely on humans to process all the information. Automatic text processing systems are obvious solutions to the information overload problem. The TIPSTER program, sponsored by multiple U.S. government agencies (Harman 1994), has spurred even greater interest in automatic text processing studies among academic and private research groups. In this paper, we describe the current status of SUMMARIST (Hovy & Lin 1997), an automated text summarization system, and its use in TIPSTER Phase III text summarization research.

Overview of SUMMARIST

The goal of SUMMARIST is to generate summaries of multilingual input texts although SUMMARIST only processes English texts at this time. SUMMARIST combines existing robust natural language processing methods (morphological transformation and part-of-speech tagging), symbolic world knowledge (WordNet (Miller *et al.* 1990) and dictionaries), and information retrieval techniques (word counting and term distribution) to achieve high robustness and better concept-level generalization.

The core of SUMMARIST is based on the following 'equation':

$$\begin{aligned} summarization \quad = \quad & topic\ identification + \\ & topic\ interpretation + \\ & generation \end{aligned}$$

The functions of these three stages are briefly described as follows:

Topic Identification: Identify the most important (central) topics of the texts (Lin 1997). SUMMARIST uses positional importance (Edmundson 1969; Paijmans 1994; Lin & Hovy 1997), cue phrases (Edmundson 1969; Paice 1990; Teufel & Moens 1997), and word counting. Discourse structure-based importance will be added later (Marcu 1997; Kando 1997).

Topic Interpretation: To fuse concepts such as *waiter*, *menu*, and *food* into one generalized concept *restaurant*, we need more than the just simple word aggregation used in traditional information retrieval. SUMMARIST employs concept counting (Lin 1995) and topic signatures (Lin 1997) to tackle the fusion problem.

Summary Generation: SUMMARIST will be able to generate "summaries" in various formats such as keywords (important noun phrases), extracts (important sentences in original texts), template-based summaries (McKeown & Radev 1995) (generated from pre-specified templates), and refined summaries (generated by a sentence planner and realizer (PENMAN 1989)). However, our current system can only produce keyword and extract type summaries.

For more information regarding SUMMARIST, please visit our project website at http://www.isi.edu/~cyl/summarist. In the following section, we briefly describe the TIPSTER Phase III text summarization tasks, then proceed to discuss the current SUMMARIST implementation used in these experiments. Finally, we conclude this paper with a discussion of future directions.

Text Summarization Tasks in TIPSTER Phase III

Two tasks are devised in the initial text summarization evaluation in TIPSTER Phase III (Hand 1997). One is the categorization task. The other is the adhoc retrieval task. The categorization task is used to evaluate *generic* summaries, which are summaries based on what is important in the original texts. The adhoc retrieval task is used to evaluate *user-directed* summaries, in which are summaries created according to user queries.

Generic summaries can replace the original texts to speed up text categorization; while user-directed summaries can be integrated with an information retrieval engine to help users quickly judge the relevancy of the retrieved documents. SUMMARIST currently only produces generic summaries. Adhoc retrieval capability will be added later. In the following section, we describe how SUMMARIST generates generic summaries using various text processing modules.

SUMMARIST in TIPSTER Phase III

SUMMARIST consists of several text processing modules. Each module either performs certain preprocessing tasks (such as tokenization) or attaches additional features (such as part-of-speech tag) to the input texts. These modules are summarized in the following:

tokenizer : reads English texts and outputs tokenized texts.

part-of-speech tagger : reads tokenized texts and outputs part-of-speech tagged texts. This tagger is based on Brill's (Brill 1992) part-of-speech tagger.

converter : converts tagged texts into SUMMARIST internal representation.

morpher : finds all the possible root forms of the input tokens, using a modified WordNet (Miller *et al.* 1990) demorphing program.

phraser : finds all the possible collocations (multiword phrases) based on WordNet.

token frequency counter : counts the occurrence of each token in an input text.

$tf \cdot idf$ **weight calculator** : calculates the $tf \cdot idf$ (Salton 1988) weight for each input token, and ranks the tokens according to their $tf \cdot idf$ weight.

clustering module : clusters texts according to their similarity. The minimum number of documents per cluster is set to regulate the size of a cluster. Complete-link algorithm (Frakes & Baeza-Yates 1992) is used in the current setup.

These helper modules prepare necessary inputs for high level processing units such as the Position Method module, Topic Signature module, and the final Integration module. We describe these modules in the following sections.

Position Method

The position method is based on the assumption that sentence position correlates with importance in genres with regular structure (Edmundson 1969). (Lin & Hovy 1997) proposed a method, Optimal Position Policy (OPP), to identify importance sentence position automatically. For example, the ranking of sentence importance according to position for Ziff-Davis texts is:

{title, P2S1, P3S1, P4S1, P1S1, P2S2, (P3S2, P4S2,...),...}

where P is the paragraph number and S is the sentence number within a paragraph. For the TIPSTER Phase III experiment, we used hand-produced OPPs for each possible source since no training summaries were available. The Position Method module also computes local and global OPP weights for each input token. The local OPP weight of a token is a function depending on the sentence OPP rank containing the token. The global OPP weight of a token is the sum of all the local OPP weights of that token over all sentences.

Cue Phrases

Phrases such as "in summary", "in conclusion", and superlatives ("the best", "the most important") are good indications of important content (Edmundson 1969). Cue phrases are sometimes genre dependent. For example, "we conclude" or "in conclusion" is more likely to occur in scientific literature. For this initial TIPSTER Phase III experiment, we manually compiled a list of cue phrases from the training corpus. Different sets of cue phrases were used depending on the source[1] of the input texts. We are currently examining methods to automatically generate cue phrases.

Topic Signatures

Topic signatures (Lin 1997) provide a way to represent concept co-occurrence patterns. For example, a concept co-occurrence pattern for topic *earthquake* would consist of several key concepts such as *Richter scale*, *death toll*, and *magnitude* which together uniquely identify it. Notice that any of these concepts alone can not pinpoint the topic *earthquake*.

A signature for a topic is the topic and a list of its $< keyconcept, weight >$ pairs, where *weight* is the relative strength of the corresponding concept associated with the topic. We currently use $tf \cdot idf$ weight. For example, the topic signature for *earthquake* can be represented as follows:

[*earthquake*, (*Richter scale*, w_1), (*death toll*, w_2), (*magnitude*, w_3), ...]

Topic signatures can be acquired in two ways. If pre-categorized training texts are available, then we use the most significant N words according to some term weighting scheme to form topic signature for each category; if not, we can cluster similar texts together, use the resulted clusters as informed categories, and proceed as the former. Although topic category and relevance judgement for each text was available to us in the initial TIPSTER Phase III evaluation, we were not allowed to use them. Therefore, a clustering step was necessary for topic signature construction. Figure 1 shows the topic signatures for three clusters and their corresponding topics. Please note that signatures 4 and 6 are related to similar broad topic area, i.e.,

[1] For this initial TIPSTER Phase III evaluation, texts are from Wall Street Journal, Associated Press, Department of Energy Abstracts, and Federal Register.

"Iranian Support for Lebanese Hostage-takers". However, our clustering module identified two sub-topic areas within the general topic area. Sigature 4 is more about terrorist acts; while signature 6 is more about Moslem political affairs. The signature-based module in SUMMARIST first matched an input text with a set of precompiled signatures, and then the signature words of the most similar signature which occur in the text are extracted as keywords and appended to the summary.

The utility of concept co-occurrence has been demonstrated in other research. Artificial Intelligence techniques have been tried in topic identification (DeJong 1979; Mauldin 1991; Riloff & Lehnert July 1994). The major differences between topic signatures and the other techniques are that topic signatures can be acquired through statistical training and have a simpler structure. (Lin 1995) proposed a method to generalize concepts according to inter-concept relations such as *is_a*, *part_of*, *member_of*, and *substance_of* using a concept taxonomy (WordNet). This method can be integrated with the topic signature method to provide a more systematic organization for the automatically generated signatures.

Integration

How to combine various output from different SUMMARIST modules is a main focus in our research. Ideally, we would like to have a magic function that takes the output from each module and produce the best summary. However, it is difficult to estimate the magic function without further understanding of the interaction among SUMMARIST modules. One solution is to learn the function if gold standard summaries are available. (Kupiec, Pedersen, & Chen 1995; Teufel & Moens 1997) have been successful to some extent along this line. We plan to pursue this direction in the near future. SUMMARIST currently only uses simple hand-crafted heuristic rules to combine output from different modules.

The principal selector rule for the initial TIPSTER Phase III evaluation is based on genre, which is determined by the source of texts. We used OPP for Associated Press and Wall Street Journal articles, and cue phrase for Federal Register and Department of Energy Abstract. Additionally, we added OPP, signature, and $tf \cdot idf$ keywords at the end of each summary. In the next section, we present two examples from the initial evaluation training and dryrun corpus.

Examples

Figure 2 shows the preamble portion of the internal format of text AP890417-0617, as produced by SUMMARIST. It includes a unique document number (docno), the title of the document (title), modules touching the document (module), token frequency statistics (freq[2]), $tf \cdot idf$ selected keywords (tfidf_keywords[3]), top three most similar topic signatures, (signature[4]), signature selected keywords (sig_keywords), OPP selection rules (opp_rule[5]), and OPP selected keywords (opp_keywords). Notice that keywords selected by $tf \cdot idf$, signature, and OPP are not all the same.

Figure 3 shows the content portion of the internal format of text AP890417-0617 processed by SUMMARIST. Each line starts with a word and followed by its attribute list[6].

Figure 6 shows the original text of document AP890417-0617. Figure 4 is the generic summary generated by SUMMARIST. Since document AP890417-0617 is an Associated Press text, OPP is used and the top 4 paragraphs are selected. Also, $tf \cdot idf$, signature, and OPP selected keywords are appended at the end of the summary. The keyword list presents a keyword type short *sub-summary* of the part of the text not covered by the portion selected by OPP.

To demonstrate how the cue phrase module is used in practice, Figure 5 shows a Department of Energy Abstracts with the summary selected by SUMMARIST highlighted. Cue phrases *this paper ...* and *we conclude ...* are good indicators of important content in the abstract. This example indicates the possibility of summarizing a summary.

Conclusion

In this paper, we introduced the assembly of topic extraction modules in SUMMARIST and its use in the initial TIPSTER Phase III evaluation. Although the functions of current SUMMARIST are by no means sophisticated, we are encouraged by the fact that various modules of SUMMARIST are integrated and perform well together to carry out some preliminary summary tasks. We also demonstrated that clustering provides a way to create many signatures, which are useful for both topic identification and interpretation.

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[2]The first number is the total number of tokens. The second number is total minus number of punctuation. The last one is total number of content words.

[3]Each bar-separated pair consists of the tfidf term and its weight. Terms are listed in descending weight order. The same format is used in sig_keywords and opp_keywords.

[4]The first number is the cluster number and the second one is the similarity of this signature to the document.

[5]OPP rule can be applied to either paragraph or sentence, indicated by p: or s:. Vertical bars separate each position pair, which is a paragraph or sentence number followed by its rank. Title is indicated as paragraph 0.

[6]Each attribute is separated by a space. The meaning of each attribute is: [pno, paragraph number], [sno, sentence number], [pos, part-of-speech tag], [cwd, common word (true or false)], [mph, root form], [frq, frequency count], [tfidf, tfidf weight], [sig, signature weights of the top three most similar signatures], [cue, cue phrase], [opp, OPP weight (global, local)].

#2		*#4*		*#6*	
inmate	12.28	hostage	12.17	iranian	15.20
prison	10.50	shiite	9.83	hostage	5.79
prisoner	4.08	hold	9.62	western	5.36
jail	3.67	israeli	8.28	asset	4.39
county	3.63	bush	8.19	ayatollah	3.89
sunday	2.89	western	6.85	bush	3.81
correction	2.78	moslem	6.10	gulf	3.76
riot	2.35	kidnap	6.10	minister	3.73
guard	2.27	sheik	5.31	hussein	3.69
cell	2.26	iranian	5.00	parliament	3.45
court	2.16	release	4.50	quote	3.38
department	2.13	god	3.86	revolutionary	3.29
hold	2.01	middle	3.79	shiite	3.23
federal	2.00	kill	3.73	ali	3.21
serve	1.98	west	3.58	interior	3.17
police	1.91	american	3.51	persian	3.00
convict	1.86	hussein	3.51	sunday	2.98
camp	1.84	sunday	3.51	revolution	2.92
escape	1.79	march	3.40	radical	2.72
saturday	1.75	east	3.36	republic	2.66
sheriff	1.74	syrian	3.33	cabinet	2.65
city	1.72	free	3.07	iraqi	2.59
overcrowding	1.68	abduct	3.05	moslem	2.57
percent	1.67	amal	3.01	west	2.51
cuban	1.63	terrorist	2.95	release	2.49

signature #2: Coping with Overcrowded Prisons
signature #4: Iranian Support for Lebanese Hostage-takers I
signature #6: Iranian Support for Lebanese Hostage-takers II

Figure 1: Three topic signatures and their related TREC topics.

⟨*docno=AP890417-0167⟩
⟨*title="Former Hostage Accuses Britain of Weakness ."⟩
⟨*module=PRE|POS|MPH|FRQ|IDF|SIG|CUE|OPP⟩
⟨*freq=544,471,253⟩
⟨*tfidf_keywords=france,13.816| holding,9.210| hostage,8.613| iranian,8.342| television,8.342 ...⟩
⟨*sig_keywords=hostage,12.169| hold,9.623| western,6.855| moslem,6.104| iranian,5.001| release,4.506 ...⟩
⟨*signature=#4,0.577|#2,0.455|#6,0.387⟩
⟨*cue=p:-,- s:-,-⟩
⟨*opp_rule=p:0,1|1,2|2,3|3,4|4,4 s:-,-⟩
⟨*opp_keywords=kauffmann,4.578| release,3.866| britain,3.811| mccarthy,3.594| hostages,3.406| british,3.150 ...⟩

Figure 2: Preamble of text AP890417-0617, produced by SUMMARIST.

Former ⟨pno=1 sno=1 pos=JJ cwd=1 mph=- frq=1 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=-,-⟩
hostage ⟨pno=1 sno=1 pos=NN cwd=0 mph=- frq=6 tfidf=8.613 sig=1,12.169|33,1.370|2,5.791 cue=0,- opp=2.445,0.898⟩
John-Paul ⟨pno=1 sno=1 pos=NNP cwd=0 mph=- frq=1 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=0.898,0.898⟩
Kauffmann ⟨pno=1 sno=1 pos=NNP cwd=0 mph=- frq=6 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=4.578,0.898⟩
on ⟨pno=1 sno=1 pos=IN cwd=1 mph=- frq=4 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=-,-⟩
Monday ⟨pno=1 sno=1 pos=NNP cwd=0 mph=- frq=3 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=2.076,0.898⟩
urged ⟨pno=1 sno=1 pos=VBD cwd=0 mph=urge frq=1 tfidf=0.000 sig=-,-|-,-|274,0.492 cue=0,- opp=0.898,0.898⟩
Britain ⟨pno=1 sno=1 pos=NNP cwd=0 mph=- frq=4 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=3.811,0.898⟩
to ⟨pno=1 sno=1 pos=TO cwd=1 mph=- frq=12 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=-,-⟩
follow ⟨pno=1 sno=1 pos=VB cwd=0 mph=- frq=1 tfidf=3.381 sig=-,-|-,-|299,0.466 cue=0,- opp=0.898,0.898⟩
the ⟨pno=1 sno=1 pos=DT cwd=1 mph=- frq=24 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=-,-⟩
example ⟨pno=1 sno=1 pos=NN cwd=1 mph=- frq=1 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=-,-⟩
set ⟨pno=1 sno=1 pos=VBN cwd=0 mph=- frq=1 tfidf=2.847 sig=-,-|149,0.540|-,- cue=0,- opp=0.898,0.898⟩
by ⟨pno=1 sno=1 pos=IN cwd=1 mph=- frq=4 tfidf=0.000 sig=-,-|-,-|-,- cue=0,- opp=-,-⟩
France ⟨pno=1 sno=1 pos=NNP cwd=0 mph=- frq=2 tfidf=13.816 sig=27,2.835|-,-|-,- cue=0,- opp=1.569,0.898⟩

Figure 3: Word-attribute list of text AP890417-0617, produced by SUMMARIST.

⟨DOC⟩
⟨PARTICIPANT⟩⟨/PARTICIPANT⟩
⟨TASKTYPE⟩adhoc⟨/TASKTYPE⟩
⟨SUMMARYTYPE⟩best⟨/SUMMARYTYPE⟩
⟨QNUM⟩138⟨/QNUM⟩
⟨DOCNO⟩AP890417-0167⟨/DOCNO⟩
⟨TITLE⟩Former Hostage Accuses Britain of Weakness ⟨/TITLE⟩
⟨TEXT⟩ Former hostage John-Paul Kauffmann on Monday urged Britain to follow the example set by France and West Germany and negotiate the release of its citizens held captive in Lebanon .
Kauffmann said Britain " has abandoned " John McCarthy , 32 , a television reporter abducted on his way to Beirut airport .
" British officials say they won't negotiate because it will only lead to the taking of other hostages , " Kauffmann told a meeting to mark the third anniversary of McCarthy 's kidnapping .
" I say you can negotiate without giving in . "
The French and West German governments managed to secure the release of their hostages without being brought to their knees , Kauffmann said at the meeting organized by British and French journalists .
Keywords:
western moslem iranian middle kill march east syrian free anderson group palestinian
⟨/TEXT⟩
⟨/DOC⟩

Figure 4: Generic summary for text AP890417-0617, generated by SUMMARIST.

⟨DOC⟩
⟨DOCNO⟩ DOE1-56-0183 ⟨/DOCNO⟩
⟨TEXT⟩
Projections of levels of radioactive fallout from a nuclear war are sensitive to assumptions about the structure of the nuclear stockpiles as well as the assumed scenarios for a nuclear war. Recent arms control proposals would change these parameters. **This paper examines the implications of the proposed (Intermediate-range Nuclear Forces) INF treaty and (Strategic Arms Reduction Treaty) START on fallout projections from a major nuclear war. We conclude that the INF reductions are likely to have negligible effects on estimates of global and local fallout, whereas the START reductions could result in reductions in estimates of local fallout that range from significant to dramatic, depending upon the nature of the reduced strategic forces.** Should a major war occur, projections of total fatalities from direct effects of blast, thermal radiation, a nd fallout, and the phenomenon known as nuclear winter, would not be significantly affected by INF and START initiatives as now drafted. 14 refs.
⟨/TEXT⟩

Figure 5: Highlighted summary for text DOE1-56-0183, generated by SUMMARIST.

The successful integration of various SUMMARIST modules proved that the modular approach adopted by SUMMARIST is practical and rewarding, since each module can be developed and tested separately and new modular can be added to improve system performance. We plan to add more modules, including a proper name recognizer, anaphora resolver, and discourse structure analyzer, in the near future. How to generate query-sensitive (user-directed) summaries is also a main focus in our future investigation.

Acknowledgements

The author would like to thank Eduard Hovy for valuable discussions and suggestions. Eduard Hovy is the principal investigator of the SUMMARIST project at USC/Information Sciences Institute. The author would also like to thank the anonymous reviewers for their comments.

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⟨DOCNO⟩ AP890417-0167 ⟨/DOCNO⟩
⟨FILEID⟩AP-NR-04-17-89 2055EST⟨/FILEID⟩
⟨1ST_LINE⟩r i AM-France-Hostage 04-17 0480⟨/1ST_LINE⟩
⟨2ND_LINE⟩AM-France-Hostage,0496⟨/2ND_LINE⟩
⟨HEAD⟩Former Hostage Accuses Britain of Weakness⟨/HEAD⟩
⟨BYLINE⟩By HARRY DUNPHY⟨/BYLINE⟩
⟨BYLINE⟩Associated Press Writer⟨/BYLINE⟩
⟨DATELINE⟩PARIS (AP) ⟨/DATELINE⟩
⟨TEXT⟩
Former hostage John-Paul Kauffmann on Monday urged Britain to follow the example set by France and West Germany and negotiate the release of its citizens held captive in Lebanon.
Kauffmann said Britain "has abandoned" John McCarthy, 32, a television reporter abducted on his way to Beirut airport.
"British officials say they won't negotiate because it will only lead to the taking of other hostages," Kauffmann told a meeting to mark the third anniversary of McCarthy's kidnapping. "I say you can negotiate without giving in."
The French and West German governments managed to secure the release of their hostages without being brought to their knees, Kauffmann said at the meeting organized by British and French journalists.
Kauffmann, a magazine writer and French citizen, was freed in May 1988 after more than three years' captivity.
France, which was under constant pressure to get back its hostages, has denied paying ransom. It complied with several Iranian demands, including banishing the main Iranian opposition group from Paris.
Kauffmann said he recently helped mark the start of the fifth anniversary in captivity of Terry Anderson, 42, the chief Middle East correspondent for The Associated Press and the longest held of 15 Western hostages in Lebanon. Anderson was abducted March 16, 1985.
"There's something cruel in these anniversaries," Kauffman said.
Those at Monday's meeting at UNESCO headquarters issued an appeal to all with influence "to do whatever they can immediately to help secure their release."
Organizer Anthony Brock, a British writer, said the appeal would be sent to U.N. Secretary-General Javier Perez de Cuellar and the Iranian and Syrian embassies in Paris.
Iran influences Moslem extremists holding the hostages, while Syria is the main foreign power broker in Lebanon.
A group working for McCarthy's release ran cinema, television and newspaper advertisements Monday.
One asked moviegoers in Britain to close their eyes and think of England, because McCarthy has "done nothing else for the last three years."
In a message with Arabic voice-over on Lebanese television, the hostage's father, Pat, told his son, "Whatever you do, old chap, keep your spirits up."
Similar messages were published in the Beirut daily As-Safir. Another message in the newspaper, signed "Jill" and apparently from McCarthy's girlfriend, Jill Morell, said: "I wish more than anything that you could be back home with us. But until then, I'm sending you all my special love."
Britain seeks the release of three of its nationals held by pro-Iranian Islamic fundamentalists _ McCarthy, Anglican envoy Terry Waite and teacher Brian Keenan, a Belfast man with dual British and Irish nationality whose release is also sought by the Irish government.
The Foreign Office says it also seeks word on Alec Collett, a New York-based British journalist whose Palestinian abductors claim they killed him. His body was never found.
⟨/TEXT⟩

Figure 6: Text AP890417-0617.