# Mining Opinion Polarity Relations of Citations

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#### 1 Introduction

Opinion mining has been receiving increasing attention recently, and various approaches have been suggested for mining sentiment information, such as mining attitudes or opinions about a topic or product etc. However, as far as we know, little work has been reported on citation opinion mining (COM). By COM, we refer to the process of identifying authors opinions towards the works they cite, such as positive/negative attitudes or approval/disapproval. We contend that such information is useful for semantic information retrieval and text mining, particularly for users who wish to search for documents taking a positive or negative stance towards a specific previous work. In this paper, we propose a system which is based on existing semantic lexical resources and NLP tools, aiming to create a network of opinion polarity relations between documents and citations. This is a web-based system which allows users to access the citations collected from documents and retrieve those documents linked to each of the citations with different opinion polarity relations, namely approval, neutral or disapproval relations. Various approaches will be tested including detecting semantic orientation of subjective words in the context of citations and machine learning using manually annotated data. In particular, we will explore the use of semantic lexicons for this task.

#### 2 Related work

Recently, opinion mining has emerged as an important research area cutting across a number of topics such as information retrieval, NLP and text mining etc. Research in this area covers several topics including the learning of semantic orientation of words/terms, sentiment analysis of documents, analysis of opinions and attitudes towards certain topics or products etc. Previous works closely related to our current work include Wilbur et al. [8], Teuful et al. [7] and Kim and Hovy [3].

Wilbur et al. (2006) suggest that factual information mining is not sufficient. There is a range of non-factual qualitative information which affects the reliability and validity of factual information. For example, when authors discuss individual facts, some may be speculative, e.g. we assume that X can be linked to Y while others are assertive, e.g. our result shows X is linked to Y. In their annotation scheme, they identified five qualitative dimensions that characterise a broad range of scientific sentences: Focus (scientific vs. general), polarity (positive vs. negative), certainty, evidence, direction/trend (increase / decrease in certain measurement).

Kim and Hovy [3] proposed a method for identifying opinion with its holder and topic in news media. They specifically address the issue of how an opinion holder and a topic are semantically related to an opinion bearing word in a sentence. Their method proceeds in three phases: a) identifying an opinion bearing word, b) labelling semantic roles related to the word and c) finding the holder and the topic of the opinion word among the labelled semantic roles. This is a similar method to the one proposed in this paper. However, they are different in that we are trying to determine the author's attitude of approval/disapproval towards the cited papers in the given article.

Various semantically annotated lexical resources have been developed and made available [2]. A major semantic lexicon in early days is the General Inquirer [6] (http://www.wjh.harvard.edu/ inquirer/), in which 1,915 words and 2,291 words are tagged as positive and negative respectively. Recently, more large-scale semantic lexicons have been constructed, including WordNet (http://wordnet.princeton.edu/), FrameNet (http://framenet.icsi.

berkeley.edu/), Lancaster UCREL semantic lexicon [5] and SentiWordNet [1] etc. We will explore various lexical resources for our work.

While our work is based on the previous works, it has a different aim, i.e. to mine the opinion polarity relations between documents (we refer to academic papers in this case), and their citations. As far as we know, little research has been carried out on this topic.

## 3 Opinion mining of polarity relations between documents and their citations

As we mentioned in the previous section, most of the previous works in the area of opinion analysis/mining have focussed on authors'/holders' opinions towards facts and topics. However, we find that opinion polarity relations between documents and their citations, such as authors attitudes of approval/disapproval towards the works they cite, can be useful for semantic information retrieval and text mining. Our assumption stems from the observation that, besides using citations as a background for their current work, authors very often take positive/negative stances towards the works of others which they cite. For example, an author may approve of a previous work and cite it as a supportive evidence for his/her own statements or points, or cite it as a negative example to be criticized in his/her article, as shown in the following sample (from PLOS http://www.plos.org/).

The PSI-BLAST program [<xref ref-type="bibr" rid="pbio-0030181-b18">18</xref>, <xref ref-type="bibr" rid="pbio-0030181-b45">45</xref>] is much more sensitive than a regular BLAST search due to the use of PSSM.

For someone who wishes to search for documents expressing approval or disapproval of a specific previous work from a large collection of documents, such opinion polarity relational information between a given document and those citing it can be useful. Obviously, it is not practical to manually analyze such information for a large amount of documents, and hence we need an automatic means of miningopinion polarity relational information.

A system model is designed for this purpose, as illustrated in Figure 1. As shown in the figure, our approach employs semantic lexicons and NLP tools to collect and map citations to form a network knit by opinion polarity relations. This approach proceeds as follows:

- Collect cited papers from a collection of academic articles (PLOS journal papers are used as sample data).
- Extract sentences containing citations of the papers from the collection.
- Link each cited work to the papers containing the citation via the sentences extracted above.
- Determine the opinion orientation of the subjective words in the context of the citations (approval, neutral, disapproval) using semantic lexical resources.
- Map the subjective words and their sentiment orientation to the citations using syntactic parse information of the sentences with the Enju parser [4] (http://www-tsujii.is.s.utokyo.ac.jp/enju/), which creates predicate-arguments links.



Figure 1: System for mining opinion polarity relations of citations

| Citation Frequency List  |                   |   |     | Citation Distribution |  |
|--|-------------------|---|-----|-----------------------|--|
| The citations frequency fait below was estructed from 20 PLOS number documents on the By Each row of the table displays the autors, pathcanon year, tife and the number of documents in which the citation   |                   |   |     | Cited doc title       | Gapped BLAST and PSI-BLAST: A new generation of protein database search programs   |
| occurs. Hyou click on any of the titles, the tool will display the citation detectibution of that document across the sample documents by collecting the sentences using the document. This system is its early<br>state wet it will be developed into a nucleare for semantic analysis of stations. |                   |   |     | No Senaco             | Sentences titing above dacument  |
| -46-3  | the at was the to | and be a particular of particular and an of particular and an of the second s |     | 1 saper-0000019 and   | Instead, we used a cutoff for the degree of similarity as reflected in the BLASTP bit scores (Aductual et al. 1997).   |
|  | Publication       | Title   | _   | 2 paper-0000019 and   | A BLASTP (Almohal et al. 1997) reserve was performed for all the proteins in each genome against the protein bank  |
| 210  | year              | Alles P   | req | 3 gaper-0000045 and   | We found orthology by searching for C. briggnars/C. elegans gene pairs that were each offer's top BLASTP (Altrichii et al. 1997) match in the opposite species.  |
|  | 1997              |   | 18  | 4 paper-0010045 am    | Cluster Y was the enon cluster with the top BLASTP (Altochul et al. 1997) hit from any of the mora in X  |
|  | 2002              | Initial requiring and comparative analysis of the mouse genomic<br>00   |     | 1 caper-0000045 and   | We can INCRUTELASTP (Attoched et al. 1997) with the C. briggene protein set as the query database and the C. elegans WST7/Rast; protein set as the target database and vice  |
|  | 2001              | Initial requestions and analysis of the human genome 0  | 05  |                       | berga.   |
| 4  | 2002              | The Ensemblagenesses database project 00  | 34  | 6 paper-0000045 and   | To identify C. elegans/human orbiology, we compared the C. elegans WS778kart, protein set to the human proteins using BLASTP (Altrichil et al. 1997) with the SEG filter   |
| 5  | 1997              | ZAML A response sockaar for abstractive analysis by maximum likelihood 00   |     |                       | (Wootton and Federina 1996).   |
|  | 1997              | IENArcan-SE: A program for improved detection of transfer ENA genes in genomic sequence 00  | 33  | 7 paper-0300045 and   | To predict rRNA and mRNA genes, we extracted sequences from the sequence databases and reacted for homologous requences in the C brigging genome using BLASTN<br>(Abrohul et al. 1997).  |
|  | 1997              | Becherichia cui K-127+The complete genome requests of Rocherichia cui K-12  |     | 2 August 0000015 and  | We then used BLAST (Altochal et al. 1997) to identify and remove trusted repeat resources from the DNA resources of the C. cleanst and C. brianties are sets.  |
| 8  | 1986              | Sample methods for estimating the numbers of processors and neuronovarias methodole substitutions   | 03  |                       | We want the second |
| 9  | 2004              | Dirac conserved elements in the human genome 00   |     | 9 paper-0300045 and   | the series of the second  |
| 10   | 2003              |   | 02  | 10 paper-0020009 and  | We ran the BLASTP 2.2.2 (Altricht) et al. 1997) locally in order to determine the resource similarity among all coding regions.  |
| 11   | 2003              | Con-determination gene and pathway evolution in normal-day  | 32  | 11 paper-0020055 and  | To identify deplicate and mighton gener, a reciprocal posterin BLAST (Altechal et al. 1997) was performed on the proteomer of the two study organisms using default parameters   |
| 12   | 2003              | Riter, An RNA family database   | 72  | 11 paper-0020000 324  | and nimple requires fibring  |
|  | 2003              | Origina of highly messis, myredowini enhage generate 00   |     | 12 sager-0020160 and  | All-against-all comparison of genes belonging to human, yeast, P. provanskii, and Encephalitozoon canitoli genomes has been conducted using the PSI-BLAST algorithm (Altricht  |
| 4  | 2003              |   | 22  | -                     | 84.090   |
|  | 2002              | The Yim protein funders database 00   | 32  | 13 paper-0020162 and  | Folds were anigned by reverse PSI-BLAST (Altribut et al. 1997) marches of the aniso acid requences derived from the H-law tDNA against the SCOP database (Lo Conte et<br>al. 2010)   |
| 16   | 2002              |   | 32  | _                     | pa. 2000.<br>Thiese otherwise indicated, SNPs were aligned to other sequences only when a verfect (33/37) base match was obtained using BLAST (Altribut et al. 1997) with one or the other   |
|  | 2002              | Wagging working dominida?> Genome requestor of the endocedular obligate symbols of torse files, Wagderworking dominida  | 02  | 14 paper-0020068 and  | others supremain and out others were appress our requires our were a price (2003) our many was common and attact (another in 1997) was one or an our   |
|  | 2002              | Terrinia periti KBM+Gmome requesce of Versia periti KBM   | 32  |                       | To merey conservation in the rest determination reducers between C. element and C. brinsmas we used reciprocal best RLAST dilasts 37.38.39/denois. to identify rotantial C.  |
| 19   | 2002              |   |     | 15 paper-0030006 and  | briggnas orthology of 31 known C. alagana sex determination genes, rome of which have been previously identified.  |
| 10   | 2002              | Eubacterial phylogeny bared on transfational apparatus proteins 00  | 32  | 16 gager-0130007 and  | These were located by comparing the CHEs to the microRNA Registry dilugh, 72 design, and the Rims database (version 5.0) dilugh, 72 design, sugg BLASTn dilugh, 74 design,   |
| 21   | 2002              | A phylogenetic approach to batterial phylogenzy Deidence of a core of gener charing a common history 00   | 22  | 17 paper-0030042 and  | We used reciprocal best-bits BLAST & thep, 33 & reply, to identify requences or the logout to the tuman requences in the reference assembly of the whole genome shotgan assembly   |
| 22   | 2001              | The response of the harvan genome 00  | 32  |                       | of the charpenne genome.   |
| 23   | 2001              |   | 20  |                       | Esmolograss genes (and revolving gene families) were defined using a costil for the degree of similarity among proteins reflected in the Marp bit scores & logic 50 & robi.  |
| 14   | 2001              | Nanodas INA asse deterios unas concastas acases a subsi-  | 12  |                       | In mother search against GenBunk, using PSI-BLAST dduph, 18draugh, (see Matemia and Methods) with the Transh2ddowbar,AG TPase as a query, we found that two  |

Figure 2: Citation frequency list linked to citation distributions

- Based on the sentiment analysis of the sentences, induce opinion polarity relations between the papers and citations.
- Create a network of papers knit by the opinion relations and save it in a database.
- Provide a search interface for the system.

Semantic lexical resources form a core component of this system which provides clues for subjective word polarity orientation. As a starting point, we will test Lancaster's UCREL semantic lexicon (http://www.comp.lancs.ac.uk/ucrel) and the General Inquirer lexicon. However, we will including more lexical resources in future.

This system is still in its early stages of development, but a prototype implementing a number of the steps has been developed. Currently, the prototype is capable of collecting cited papers with citation frequencies (in terms of number of documents) from a given collection of PLOS articles and extracting a citation distribution list for each of the cited papers i.e. a list of sentences containing the given citation. Figure 2 shows a snapshot displaying a citation frequency list and a citation distribution list. In this figure, the left-hand webpage displays the list of cited papers extracted from a collection of PLOS articles, and the right-hand one displays the sentences containing the citations found in the paper collection.

After completion, this system would enable users, for a given document, to retrieve other documents which cite it with certain sentiment orientation. For example, the user can retrieve academic papers that approve of an earlier work by following the positive sentiment links of citations. The documents and sentences will be classified into the categories of approval, neutral and disapproval relations with respect to the paper they cite. All of the information will be accessible via a web interface, as illustrated by Figure 1.

#### 4 Conclusion

In this paper, we briefly described a system model of citation opinion polarity mining which is under development. Our work is motivated by our assumption that such opinion polarity relations between documents and their citations are useful information for advanced semantic information retrieval and text mining. Although much research has been conducted in opinion mining area, as far as we know, little work has been done on opinion mining regarding citations. If an efficient system can be developed for mining opinion polarity relations of citations, it will be helpful in enhancing current text mining systems which currently are generally based on factual information. In particular, considering the huge amount of biomedical literature, this work will bring benefits to biomedical text mining tools for further refining search results.

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