

Whetting the Appetite of Scientists: Producing Summaries Tailored to the Citation Context

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ABSTRACT

The amount of scientific material available electronically is forever increasing. This makes reading the published literature, whether to stay up-to-date on a topic or to get up to speed on a new topic, a difficult task. Yet, this is an activity in which all researchers must be engaged on a regular basis. Based on a user requirements analysis, we developed a new research tool, called the *Citation-Sensitive In-Browser Summariser* (CSIBS), which supports researchers in this browsing task. CSIBS enables readers to obtain information about a citation at the point at which they encounter it. This information is aimed at enabling the reader to determine whether or not to invest the time in exploring the cited article further, thus alleviating information overload. CSIBS builds a summary of the cited document, bringing together metadata about the document and a contextualised summary that exploits the citation context to retrieve the sentences from the cited document that are relevant at this point. This paper briefly presents our user requirements analysis, then describes the system and, finally, discusses the observations from an initial pilot study. We found that CSIBS facilitates the relevancy judgment task, by increasing the users' self-reported confidence in making such judgements.

Categories and Subject Descriptors

H.2.8 [Database Applications]: Scientific databases; H.5.2 [User Interfaces]: Natural language, User-centered design; H.5.4 [Hypertext/ Hypermedia]: Navigation, User issues

General Terms

Design, Human Factors

Keywords

Information needs; Information browsing; Scientific Literature; Biomedical Researchers; User Modeling and Interactive IR; Summarization

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1. INTRODUCTION

Researchers regularly browse through repositories of online academic literature to update their existing knowledge or to quickly familiarise themselves with a new topic. In a survey we conducted of biomedical researchers, for example, we found that two-thirds of participants browsed the academic literature at least once a week. Like many knowledge workers, they are increasingly time poor. That, coupled with a near exponential growth of available publications and scientific material, makes the task of browsing through and staying up-to-date with academic literature a particularly onerous one. With the growing body of on-line material, there is both an opportunity and a need to develop new tools to support researchers in this browsing task and to help them make decisions about the relevance of articles:

There are typically two means of finding documents that address the researcher's information needs: searching and browsing. By *searching*, we might find relevant material through queries posted to search engines. We also regularly expect to find additional important information by *browsing* through documents and following potentially relevant citations.

As one reads a document (the *citing* document), a large number of citations may be encountered. Each citation points to a *cited* document and is embedded within a *citation context*. While some tools (for example, *ScienceDirect*¹) enable the reader to obtain, at the point of citation, the full details of the bibliographic reference, this is often insufficient information to determine if the referred-to work is worth reading in full. This is the problem we address here: we want to support researchers in determining whether a cited document is relevant to their needs and whether they should go to the trouble and cost of obtaining it. We present the *Citation-Sensitive In-Browser Summariser* (CSIBS) a tool that supports readers in deciding which cited documents they should read. CSIBS was developed based on a user requirements analysis, which revealed two prominent tasks: appraising the cited document and determining if the citation was justified. Ultimately, in performing these two actions, the reader is trying to decide whether or not to read the cited document in full, and it is this overall task that CSIBS strives to facilitate.

CSIBS helps readers browse and navigate through a dense network of cited documents. It does this by presenting to readers, at the point of citation, a summary of the cited document. The summary contains both important metadata about the cited document (e.g., the author's affiliations

¹See www.sciencedirect.com.

or the impact factor of the host journal) and key sentences extracted from the cited document, *based on the citation context* (or the reader's reading context).

The key observations here are that, while the meta-data about the document might enable the reader to appraise the cited document, the contextualised summary (the portion of the summary sensitive to the reading context) provides information that can support the reader in determining whether the citation is justified in its context. Our hypothesis is that the content of this citation context can allow CSIBS to determine what information in the cited document will be of most value, given what has just been read by the reader in the citing document. This portion of the summary is built using automatic text summarisation methods that exploit the links and anchor texts in hypertext documents [14].

The summary is shown as a pop-up text box within the same browser in which the citing document is being viewed (for example, Adobe Acrobat Reader or a web browser). The integration of this support into the browser, by overlaying summaries on top of the citing document, enables readers to maintain their focus of attention by providing relevant snippets tailored to their information needs. In doing so, CSIBS aims at helping to avoid following irrelevant citations. An added advantage is that the original reading task is not disrupted.

The summary is activated either by moving the mouse over a citation or by double-clicking on the citation itself. The former simply provides the summary, while the latter allows the user to copy and paste the generated summary. To provide these interaction modes, CSIBS exploits functionality provided in the implementation of Javascript pop-ups within the Adobe Acrobat Reader. Examples of this pop-up mechanism are shown in Figures 1 and 2. The work described in this paper is currently demonstrated on publication data served by databases maintained by Elsevier.²

The present paper is structured as follows. We first present related work in Section 2. Section 3 briefly describes the user study we carried out to determine the primary information needs of readers as they encountered citations; this study was carried out in the biomedical domain. Section 4 describes the design and implementation of the CSIBS system, which was based on the results of our user study. Section 5 discusses our preliminary evaluation study. Finally, Section 6 presents our current on-going and future research interests, while Section 7 concludes the paper.

2. RELATED WORK

The tasks of users in academia, specifically in the humanities [1] and in mathematics [15], have been studied previously, revealing a number of teaching and research activities that might be supported by technology. In this work, we are specifically interested in supporting the task of making a relevance judgement about a cited document. In particular, CSIBS is aimed at supporting users in the science disciplines.

An analysis of document usages for collections of scientific text has been carried out in [3]; this analysis reveals the types of queries users make in search engines oriented towards large-scale scientific literature repositories. Our analysis differs in that we seek to understand the user's scenario in terms of information needs and the underlying tasks be-

ing performed, particularly in the context of browsing, as opposed to searching, through literature.

To facilitate these tasks, we investigate technologies that are able to locate and present useful information from within academic documents. Other research has addressed similar goals: the extraction of tabular information from within scientific documents has been explored [5]; and key phrases from scientific publications are identified in [9], taking document structure into account. In this paper, we are interested in extracting sentences that justify the citation context, thus helping readers make a relevance judgement about the cited document.

Sentence-related extraction technologies have been explored within the field of automatic text summarisation, although with a differing application perspective from ours. The detection of sentences with citation information has been studied in the context of patent information by [6] (for Japanese documents). In earlier work, such sentences were used for the automatic compilation of survey articles [7].

Summarisation through the use of co-citation information has also been explored. An overview is provided in [2]; in that work, the authors analyse the similarity between citation contexts for a particular document. Similarly, [11] presented an approach for summarising an academic document based on the citations of that document found in the literature at large. Citation contexts have also been classified according to the rhetorical role that they play in the document that is currently being read [13]. Given this classification, cited documents are summarised by showing sentences that support the specific rhetorical role. These approaches are similar to ours in that they exploit the use of citations between documents as linkages. However, except for [13], these approaches can only produce summaries that are independent of the reading context, while our approach deliberately tailors a summary to the citation context that has just been read. Our work differs from [13], in that we tailor the summary to the content of the citation context and not the rhetorical role.

There are a number of products that also cater to users in the academic domain. Knowledge extraction systems focusing on biomedical text, such as *BioMed Experts*,³ *Illumin8*,⁴ and *ConceptWeb*,⁵ can automatically extract facts or highlight linkages (for example, by using clustering approaches) between researchers and published research. Often these tools provide improved search interfaces by suggesting ways in which to expand a query. These tools are complementary to browsing-oriented tools like CSIBS. Once documents are found, researchers can use CSIBS to navigate further through the space of document citations.

Reference managers, such as *Sente*⁶ and *JabRef*,⁷ can automate many tedious processes, such as automatically downloading cited documents and populating bibliographic databases. While these reduce the workload involved in obtaining referenced material, they do not help reduce the information overload on the researcher, who may still have to read each document in order to determine its relevance. Furthermore, this functionality runs the risk of placing researchers

²See www.elsevier.com.

³www.biomedexperts.com

⁴www.illumins.com

⁵www.wikiprofessional.org

⁶www.thirdstreetsoftware.com

⁷jabref.sourceforge.net

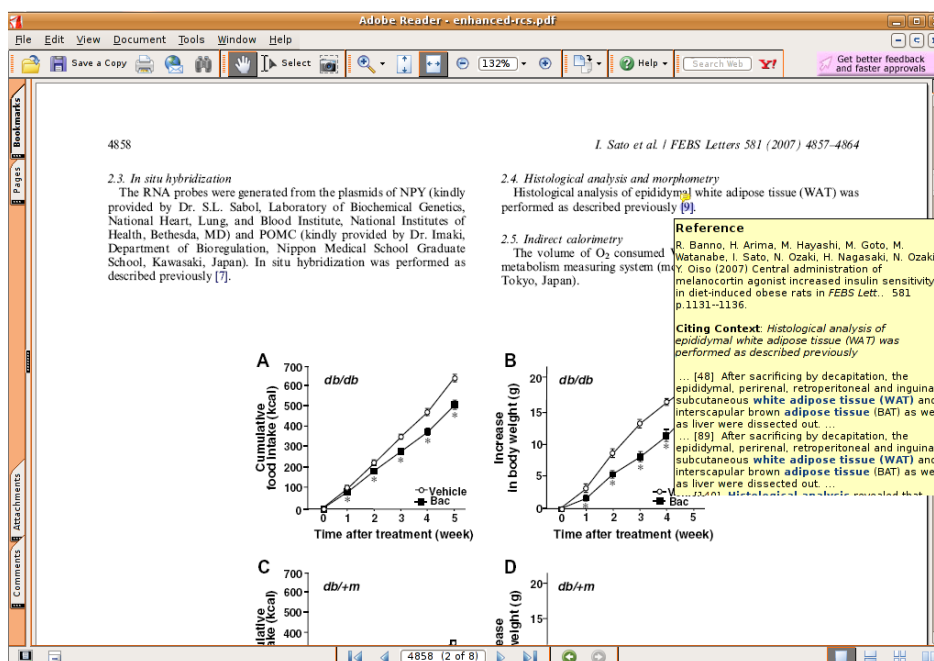


Figure 1: A sample pop-up with an automatically generated summary. This pop-up results when the user mouses over the citation. The number at the front of each extracted sentence is the original sentence position in the cited document. Words that match the citation context are coloured and emboldened.

in a situation where they do not remember why they downloaded the document: at the time of downloading, the citation context, which provides that information, is no longer readily available.

3. OUR USER STUDY

To determine what readers of scientific literature require of cited documents, we conducted a user requirements analysis. We focused on users of biomedical literature because we had access to an extensive corpus of material in this domain. However, our study and the questions we asked of participants were not specific to this domain.

We contacted thirty-six researchers in biomedical research, asking them to answer an on-line questionnaire. We explicitly stated the aims of the questionnaire by means of an initial brief. The first questions were multiple-choice questions based on general usage. For example, we asked about the reasons why participants used scientific literature and provided potential answers (e.g., "To learn about a new topic", "To update your knowledge on a particular topic", "Other: please specify"). We also asked them about the frequency of their literature browsing activity. Twenty-four participants completed that part of the questionnaire. Two thirds reported that they browsed through academic literature at least once a week.

The remainder of the questionnaire was aimed at uncovering researchers' information needs and tasks while carrying out a literature search. Our aim was also to find out what made the task difficult and how it could be supported with an automatic tool. Scenario-based questions asked participants to consider their day-to-day activities, with answers provided in free text. The questionnaire was limited to ten

questions. Eighteen participants completed the entire questionnaire. Their responses were collated and analysed for commonalities, bringing to the fore those issues that were salient amongst the participants. The findings from the questionnaire can be summarised as follows:⁸

1. There were two main types of information needs, met respectively by *meta-level* and *content-oriented* information. These correspond to the tasks of *appraising the cited document* (to make a value-judgement about it) and *determining whether the citation was justified*, respectively. Both tasks in turn serve to help make a relevance judgement about the cited document.
2. The main difficulty participants reported was that of finding text that justified the citation context.
3. Searches within the document to find passages of text that justify the citation can be automated, guided by key words from the citation context, provided that the results are understandable by the user.

As a result of these findings, we chose to build a tool that meets the two types of information needs we uncovered, ultimately helping with the relevance judgement task. Our tool provides a summary of the cited document that contains both meta-data and content-oriented information, sourced from within the cited document. The former supports the article appraisal task, while the latter supports the task of citation justification; the information required is provided by automatic text summarisation techniques.

⁸A paper describing the full details of the user requirements analysis has been submitted for review.

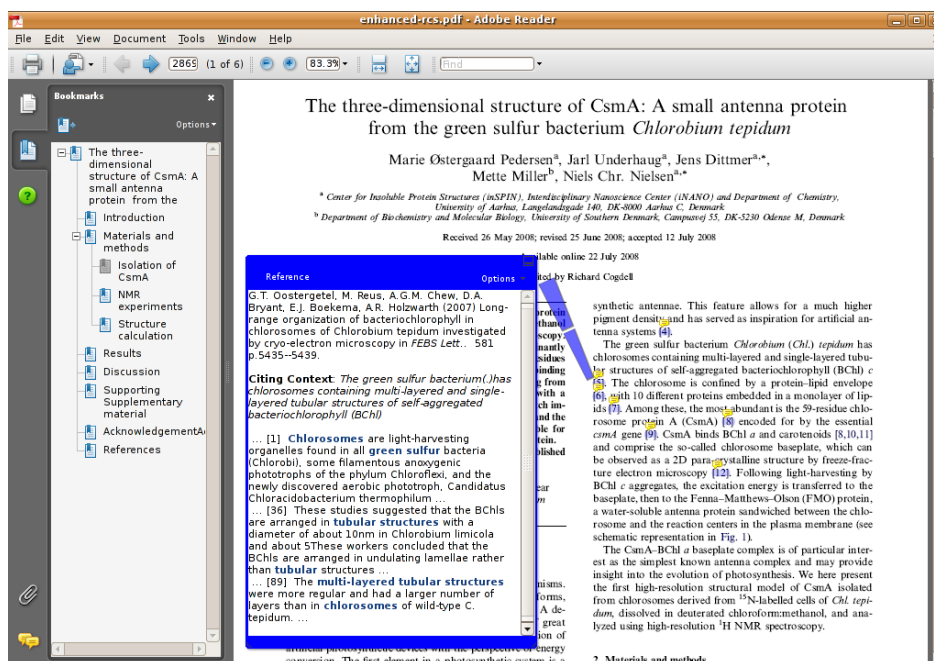


Figure 2: An alternative pop-up of an automatically generated summary. Double clicking the citation in Adobe Acrobat displays a different look-and-feel which allows the researcher to select and use the text in the summary.

4. CITATION-SENSITIVE IN-BROWSER SUMMARISATION

In this section, we provide an overview of CSIBS, focusing on how the summary is generated and delivered on multiple presentation media.

4.1 The CSIBS System

Our system architecture is presented in Figure 3. CSIBS produces an enhanced version of a published academic document, rendered either as an Adobe Portable Document Format (PDF) document or a HyperText Markup Language (HTML) web page. The enhanced document is a modified version of the original with CSIBS summaries inserted in the appropriate citation contexts. With the enhanced document, the reader can activate the summary with mouse interactions in the appropriate browser.

We now describe the process involved in generating the enhanced document using data retrieved from databases maintained by Elsevier. CSIBS is first provided with an identifier for the document that the reader has requested. This information is easily obtained from portals housing scientific data, such as ScienceDirect. The system retrieves the XML version of this document.⁹ All citation instances are identified in the XML; these are then extracted and matched with the full references at the end of the document. Meta-data for each of the cited documents is retrieved from the *EMBASE* web service.¹⁰ This provides the Elsevier-specific Publication Item Identifier (PII) number, amongst other things,

⁹While the functionality of CSIBS can be ported to other document collections, the current system assumes the availability of XML data.

¹⁰See www.embase.com.

which is used to retrieve the XML representation of each cited document from the Elsevier XML Repository.¹¹

Each citation instance, its meta-data and the XML for the corresponding cited document is then passed to the summarisation engine, which computes the summary. The resulting summary contains a subset of the meta-data for appraising the cited document, and a contextualised summary consisting of sentences extracted from the cited document to justify the citation: the meta-data corresponds to a generic view of the cited document and is independent of the citation context, while the contextualised summary will differ depending on how the cited document is referred to in the citation context. Finally, the summary is inserted into the appropriate place in the enhanced version of the published article.

To facilitate the researcher's literature browsing activities, CSIBS can be deployed as a web service attached to an existing publications portal (provided that appropriate permissions to databases are in place), so that the portal can provide the enhanced documents.

4.2 Meta-Data Summaries

CSIBS currently has functionality required to extract and present a variety of structured data, as follows:

- The full reference: This is useful in providing readers with information about the publication. It allows informal judgements based on the impact factor of the hosting journal publication, an attribute that many participants in the user study highlighted as being useful.

¹¹<http://labs-repo.elsevier.com/repo>

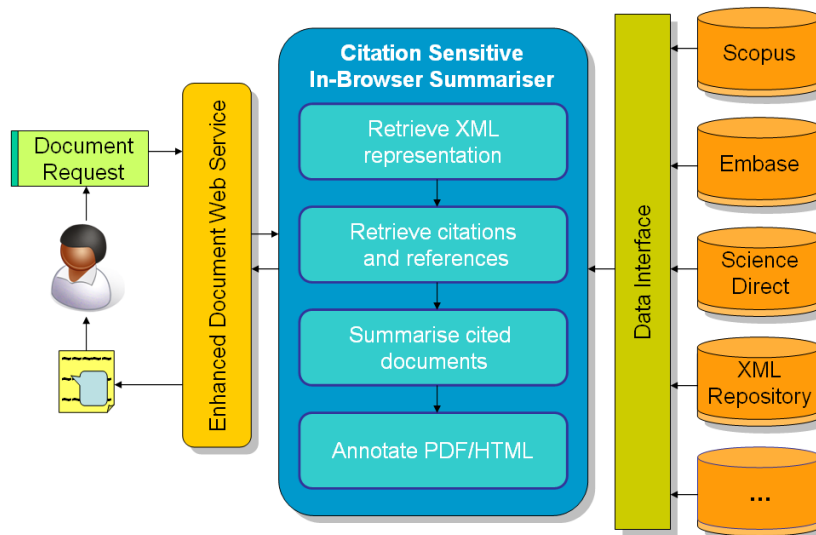


Figure 3: A system architecture diagram. CSIBS produces *enhanced* PDF documents and HTML web pages. These are delivered as a web service.

- The abstract: This is retrieved and presented as a generic overview: that is, a summary that is independent of the reading context.
- The structure of the cited document: This was also reported by participants in the user study to provide a useful snapshot of the document. CSIBS includes functionality to extract this for inclusion in the generated summary for readers to skim the cited document ‘at a glance’.
- Author Information: CSIBS can include data to help the reader establish a level of trust in the citation, primarily focusing on information about the authors’ affiliation and the number of related citations in the research area.
- The citation count for the cited document: This is extracted to help users appraise the citation.

Our development of CSIBS has been influenced significantly by the user requirements analysis briefly presented in Section 3. We have concentrated on structured data types for the appraisal task. Figure 4 presents a sample summary showing the possible meta-data as displayed in the HTML version of an enhanced ScienceDirect webpage. Figure 5 shows the same summary, this time with the abstract portion ‘expanded’ and the rest of the summary ‘hidden’. Hiding and expanding all components of the summary is a user-interface feature, implemented in Javascript.

4.3 Contextualised Summaries

4.3.1 Finding Justifying Sentences

The module that generates the contextualised summary requires, as input, the citation context and the set of sentences belonging to the cited document. The latter is easily obtained by extracting the text from the XML representation of the document and performing sentence segmentation. As output, the module produces a list of sentences for the citation justification task. These are extracted based on locating matching words (not including stop words). We cap the number of extracted sentences at a predefined limit, n , currently set to three.

To select sentences, we represent the citation context and each sentence in cited document as a vector, where each dimension represents a word in the vocabulary, and the value for that position in the vector is the term frequency. We use vector space methods [12] to find the best n sentences that match the citation context, based on the cosine similarity metric. The attractiveness of this approach lies in its simplicity, speed and scalability. This is a crucial design element for a web-based service, for which interaction times must be reasonably fast.

We have also chosen to use simple vector space approaches because the user can clearly see how results were obtained. We found this to be a desirable trait for an automated system in our user requirements analysis (see Finding 3 in Section 3). Precise word matches which are highlighted allow the reader to understand why particular sentences were extracted; additionally, the original sentence position (in the cited document) is provided and placed in square brackets, so that the reader knows roughly from which part of the document the sentence was extracted. Figure 6 presents a contextualised summary, again in the HTML version of an enhanced ScienceDirect webpage. Note that this is a summary of the same cited document as in Figure 1, which il-

Analysis and morphometry

Analysis of epididymal white adipose tissue (WAT) was performed as described previously [9].

Respirometry

Consumed VO_2 was measured with an O_2/CO_2 metabolism measuring system (model Omachikikai, Tokyo, Japan).

Activity

Activity was measured for 24 h using an activity monitoring system (model Supermex, Muromachikikai, Tokyo, Japan).

Statistical analyses

Data are expressed as mean values \pm S.E. Multiple comparisons were evaluated by a one-way ANOVA with Tukey's protected least significant difference test. Differences were considered statistically significant if $p < 0.05$.

Effect of IBA₃ receptor agonists on food intake and body weight in db/db mice

Food intake and body weight increase were significantly decreased by the administration of 100×10^{-6} g of IBA₃ in db/db mice (Fig. 1A and B). On the other hand, the same dose of baclofen did not affect body weight significantly in heterozygous db/+m mice (Fig. 1C and D). SKF 97541 and 3-APP reduced food intake and body weight increase in db/db mice (Fig. 1E and F), but not in db/+m mice (Fig. 1G and H). In separate experiments, db/db mice were given various doses of baclofen in drinking water for 5 weeks. As shown in Fig. 2A and B, any concentration of baclofen in drinking water reduced food intake and body weight increase compared to the vehicle group by the end of 5 weeks. However, the difference in cumulative food intake and body weight increase between vehicle

[9] R. Banno, H. Arima, M. Hayashi, M. Goto, M. Watanabe, I. Sato, N. Ozaki, H. Nagasaki, N. Ozaki and Y. Oiso, Central administration of melanocortin agonist increased insulin sensitivity in diet-induced obese rats, *FEBS Lett* **581** (2007), pp. 1131–1136.
[Article](#) | [PDF \(914 K\)](#) | [View Record in Scopus](#) | [Cited By in Scopus \(3\)](#)

[Summary](#)

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Figure 4: A sample pop-up summary rendered on ScienceDirect page.

illustrates the PDF rendering; however, the citation context is different, and so the resulting contextualised summary is different.

4.3.2 Narrow Information Trails

Exact token matching may, at times, fail to find the best justification sentences for citations. The optimal justification sentences might not share words with the citation context, due to differences arising from surface-level string variation, resulting from, for example, the use of synonyms or morphological variants of a word.

Ideally, the CSIBS system should record a match between two tokens where surface-level string variations exist and yet the semantics of the two words are sufficiently close. However, given the limited screen real-estate of the interface, and the need to provide understandable results, care must be taken in terms of allowing the system to relax its word matches to account for these string differences. CSIBS should not relax its sentence selection constraints only to burden the reader with poorly matching sentences, as this will merely exacerbate any existing information overload problems.

One possibility is to use manually constructed lexical resources that specify sets of related terms and synonyms. In the context of Life Sciences scientific literature, numerous biomedical ontologies exist that specify the relationships between terms. Methods for using such knowledge resources have been explored in text summarisation: the use of thesaural resources for finding topically related terms was explored in [4], and resources such as Wikipedia have been mined as a similar resource of related terms [8]. While these methods can, at times, improve the sentence matching, this comes at a cost. False positives — irrelevant sentences that

match loosely related words — can make the resulting summary unusable.

In response to this, we propose a method, *Narrow Information Trails*, that errs on the side of caution. With this method, matches with associated words are permitted only under very strict circumstances. We simply compile a list of permissible matches to related words using two hard filters:

1. we only consider words we know to be reasonable summary words for the cited document; and
2. we restrict this expanded set of words to those that have a string similarity above a certain threshold.

To construct the first filter, we investigated the use of *co-citations* as a means of identifying good summary words for a cited document. Co-citations are citation contexts in other documents in the literature that refer to the same cited document. This approach stems from the observation that the ways in which other authors refer to a document may provide an excellent and precise lexical resource of related words. This observation was also made by [11] and [6], who consider co-citation contexts as potential generic summaries (thus not tailored to the reading context).

The second filter is implemented as a function based on Levenshtein String Distance, as follows:

$$\text{Match}(s_1, s_2) = 1 - \frac{\delta(s_1, s_2)}{\max(|s_1|, |s_2|)}$$

where s_1 and s_2 are two strings of length greater than 4, and δ is the Levenshtein String Distance function. The threshold we currently use for this function is 0.5.

mal white adipose tissue (WAT) was performed as described previously [9].

O₂ was measured with an O₂/CO₂ metabolism measuring system (model Tokyo, Japan).

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mean values ± S.E. Multiple comparisons were evaluated by a one-way ANOVA/least significant difference test. Differences were considered statistically

Effect of melanocortin agonists on food intake and body weight in *db/db* mice

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[9] R. Banno, H. Arima, M. Hayashi, M. Goto, M. Watanabe, I. Sato, N. Ozaki, H. Nagasaki, N. Ozaki and Y. Oiso, Central administration of melanocortin agonist increased insulin sensitivity in diet-induced obese rats, *FEBS Lett.* **581** (2007), pp. 1131–1136. [Article](#) | [PDF \(914 K\)](#) | [View Record in Scopus](#) | [Cited By in Scopus \(3\)](#)

Summary

Authors

Abstract

In this study, we examined the effects of intracerebroventricular administration of melanotan II (MTII), a melanocortin agonist, on insulin sensitivity in diet-induced obese (DIO) rats. Although MTII treatment significantly decreased food intake and body weight for 10 days, there was no significant difference in body weight between MTII and pair-fed groups. The insulin tolerance test showed that insulin sensitivity was significantly improved in the MTII group compared to the pair-fed group. Furthermore, MTII treatment increased the number of small-sized adipocytes in epididymal white adipose tissues, suggesting that MTII increased insulin sensitivity through action on the white adipose tissues in DIO rats.

Citing Context

Reading context summary

Figure 5: A sample pop-up summary with the abstract of the cited document.

We take each word in the original citation context and compare it to words returned by the first filter. Comparisons are made using the string distance approach. Words that are above the threshold are used in addition to the words from the original citation context to select sentences. We weight the original citation context words higher using a fixed factor, currently hardcoded to be three times the original term frequency, to maintain a focus on the current reading context.

Our work has similarities with the approach in [10] which also looks at co-citation contexts as a source of paraphrase information, including synonyms. In contrast to that work, which uses deep text analysis approaches, our method, based on string difference, is targeted at variations in terms due to morphological differences. By narrowing equivalence strictly to string distance, we are able to match additional words that must *look* similar, thus making the fuzzy matching criteria transparent to the users. Additionally, we do this without the use of heuristic stemmers or manually-constructed dictionaries, which may be limited in use only to particular domains.

Figure 7 presents an example of some co-citation contexts and a diagram of the corresponding narrow information trails. The citation context shown in this example is the same as that shown in Figure 2. We use the *Scopus* database,¹² which provides documents that are co-citing. The co-citation contexts from these extra documents are extracted and used to construct the narrow information trails shown in the figure. As can be seen, this can have a beneficial impact on the contextual summary. For this citation,

¹²www.scopus.com

an additional sentence is found that now outranks previously identified justification sentences. This was found based on a matching of the additional word *Chlorobium*, which relates to the word *chlorosomes*.

4.4 The Scalability of CSIBS

The ability to generate summaries depends on the required information being available. CSIBS makes use of existing databases maintained by a publisher; the benefit of using such resources is that they provide permit response to additional database queries, such as finding all documents that co-cite a document. The time to generate an enhanced document is currently dominated by the time it takes to retrieve the cited documents. Currently, our demonstrator retrieves these documents one at a time using a research API to the repositories. In a real production system, the data would be co-hosted with the CSIBS web-service and queries to databases would be sent in parallel, thus effectively removing network lag time.

Once data has been retrieved from the databases, the time to create a summary is bounded by the number of citation contexts, c , and the largest number of sentences in a cited document, s , and has complexity $O(c \times s)$. This is almost negligible (in the order of seconds) in comparison to the data retrieval, which, once co-hosted on the same server, should no longer be an impediment.

5. THE UTILITY OF CSIBS

5.1 Evaluation Overview

A qualitative evaluation was performed to gauge whether

We have also demonstrated in a recent paper that central injection of melanotan II, an agonist for melanocortin type 4 receptors which are supposed to be downstream of leptin [24], increased serum leptin levels in DIO rats while the body weight was decreased by the injection [9]. Thus, it is possible that activating leptin signaling in the hypothalamus could potentially increase leptin release. However, the circulating leptin levels would be determined by a balance between adipose tissue and hypothalamus, although further studies are warranted to support this hypothesis.

Several kinds of drugs have been explored and used clinically for the treatment of obesity. Ciliary neurotrophic factor (CNTF), originally developed as a potential treatment for multiple sclerosis, is suggested to reduce food intake through down-regulation of leptin signaling in the hypothalamus [25]. However, the efficacy of CNTF for obesity treatment was limited by the development of the antibodies in the treated patients [26]. Our data demonstrate that baclofen has the potential to work downstream of leptin receptor and therefore increase energy expenditure in obese subjects. Furthermore, the action of baclofen is unique in that they decreased food intake and body weight only in obese subjects. Although the detailed mechanisms by which GABA_B agonists affected energy expenditure have yet to be determined, it is suggested that GABA_B agonists would decrease energy expenditure in obese subjects when they are used clinically for the treatment of obesity.

In conclusion, our data provide the first evidence that baclofen reduced food intake and increasing energy expenditure in obese mice, suggesting that baclofen could be a therapeutic reagent for obesity.

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[Annotation content](#)

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[9] R. Banno, H. Arima, M. Hayashi, M. Goto, M. Watanabe, I. Sato, N. Ozaki, H. Nagasaki, N. Ozaki and Y. Oiso, Central administration of melanocortin agonist increased insulin sensitivity in diet-induced obese rats, *FEBS Lett.* **581** (2007), pp. 1131–1136. [Article](#) | [PDF \(914 K\)](#) | [View Record in Scopus](#) | [Cited By in Scopus](#) (3)

[Summary](#)

[Authors](#)

[Abstract](#)

[Citing Context](#)

increased serum leptin levels in DIO rats while the body weight was decreased by the injection

[Reading context summary](#)

... [121] There was also a significant treatment effect on **body weight** [F(2,21)=20.1, P<0.001]. However, post hoc analyses revealed that, although **body weight** in MTII and pair-fed groups was significantly **decreased** compared to a d libitum group, there were no significant differences in changes in **body weight** between MTII and pair-fed groups (... [151] There were significant treatment effects on the **serum levels** of adiponectin [F(2,21)=35.4, P<0.01] and **leptin** [F(2,21)=7.48, P<0.01]. The post hoc analyses revealed that the **serum** adiponectin **levels** in the MTII group were significantly higher compared to either ad libitum or pair-fed groups, while there were no significant differences in the **levels** between ad libitum and pair-fed groups (... [163] There was also a significant treatment effect on **body weight** [F(2,21)=20.1, P<0.001]. However, post hoc analyses revealed that, although **body weight** in MTII and pair-fed groups was significantly **decreased** compared to a d libitum group, there were no significant differences in changes in **body weight** between MTII and pair-fed groups ...

Figure 6: This is a summary of the same cited document presented in Figure 1. However, the contents of the summary (called ‘Reading context summary’ above) are not the same because the citation context (called ‘Citing Context’ above) is different.

the generated summaries provide additional utility beyond a full reference when judging the relevance of cited documents. Three biomedical researchers, who had taken part in our initial user requirements analysis, participated in our evaluation. Each participant was asked to read a short passage containing an annotated citation and to decide if the citation was relevant given the citing context (Question 1). They were also asked whether they would follow up on the citation (Question 2). For both questions, participants had to indicate the strength of their answer on a 7-point Likert scale.

The task was performed under three conditions, depending on the pair of enhanced PDF documents presented to the participant. These were displayed within Adobe’s Acrobat Reader. In each case, the enhancement consisted of either the full reference, the abstract of the cited document, or a contextualised summary of that document. Each participant was randomly assigned to a condition and shown 9 enhanced documents, each being an article from the journal *FEBS Letters*.¹³

¹³ www.febsletters.org

In the first condition, for each trial, the participant was provided with a PDF document enhanced only with the full reference and asked to read a set passage within the document. The participant answered the two questions for the specified embedded citation. The participant was then shown a variant of the same document enhanced with the abstracts and asked to perform the same task. The second condition was the same as the first except that the second enhanced document contained a contextualised summary. The third condition was the same as the second, except that an additional task was imposed: the participant was also asked to indicate which of the three extracted sentences in the contextualised summary were useful in performing the tasks, thus providing utility feedback for each sentence. In all conditions, participants were free to ask questions. Written and verbal comments were captured throughout the evaluation.

5.2 Results

We measured the change in the strength of the responses, or the self-reported confidence, to each of the two questions. For Question 1, across the first two conditions, there was

The Citation Context:

- The green sulfur bacterium has chlorosomes containing multi-layered and single -layered tubular structures of self-aggregated bacteriochlorophyll (BChl) [citation]

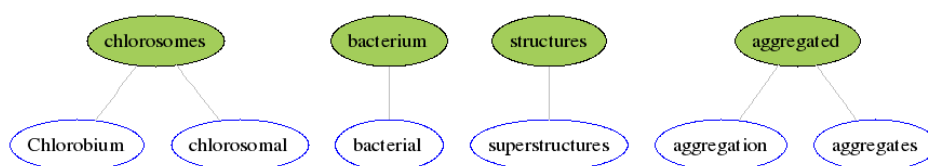
The Cited Document:

- Marie Åstergaard Pedersena, Jarl Underhauga, Jens Dittmera, Mette Millerb and Niels Chr. Nielsen. (2008) The three-dimensional structure of CsmA: A small antenna protein from the green sulfur bacterium *Chlorobium tepidum*. In *FEBS Letters*. 582. p2869-2874.

Co-Citation Contexts:

- the exact nature of BChl superstructures remain elusive and these have been controversially discussed in the literature
- cryo-TEM both on green bacterial chlorosomes from *Chlorobium tepidum*
- Either up-running stacks or down-running stacks can form extended domains, which have been imaged by TEM
- Very recent high-resolution images confirm that chlorosomes are flattened cigar-shaped nanostructures with dimensions of 20 50 200 nm
- Although the self-aggregation of BChl c, d, and e is well known, as mentioned above, the exact structure of chlorosomal aggregates has been a matter of controversial discussion for a long time
- The lamellar nature of the BChl aggregates was confirmed in a very recent electron cryomicroscopy study

Information Trails:



Additional Summary Sentence (ranked #1):

[10] The **chlorosomes** of the model green sulfur bacterium **Chlorobium** tepidum have been extensively characterized biochemically.

Figure 7: Information trails using co-citation contexts. This figure presents the original citation context, the full reference for the cited document, co-citations contexts, the information trails, and the additional matched sentence. The diagram presents words of the original citation context in filled nodes, with words from the trails in unfilled nodes. In the newly matched sentence, the new word, *Chlorobium*, is matched and thus presented in bold.

a mean change in self-reported confidence of 1.22 in favour of the abstract; and there was a mean change of 2.22 in favour of the contextualised summary. Although it is not possible to draw any firm conclusions given the small sample size, it is encouraging that the contextualised summary led to a stronger self-reported confidence. For Question 2, judgement confidence increased with a mean change in self-reported confidence of 1.33 in favour of abstracts, and 1.44 in favour of contextualised summaries. The third condition also revealed a mean utility for selected sentences of 63 per cent.

The final participant, familiar with *FEBS Letters*, made some particularly interesting observations regarding the selected sentences and the structure of the cited document. Specifically, useful sentences tended to be found deeper in the cited document, for example in the methods sections. Additionally, the participant remarked that, for corporate laboratories where each document downloaded from a proprietary repository incurs a fee, the generated summaries would make it easier to decide whether to download a document by providing a much needed citation-related preview. She also mentioned that, in the absence of sufficient information, she would err on the side of not downloading the

document.

The results suggest that providing summaries, whether they are abstracts or contextualised summaries, allows the reader to make relevance judgements with more confidence, as compared to being presented with just a full reference. The contextualised summary was useful if it offered more specific details: that is, when sentences were extracted from sections other than the introduction. We believe this is because the greater level of detail complements the genericity of the abstract.

6. FUTURE WORK

The work described in this report presents CSIBS as a proof-of-concept. In our pilot study, the tool was judged to be useful. Although CSIBS is only a research prototype, care was taken with the system design and engineering to easily optimise CSIBS in the future to scale it up for deployment as a live web service.

From a research perspective, we intend to investigate methods for tuning the summarisation performance via our narrow information trails approach. We also intend to engage further with users directly, both to obtain additional insights into information needs, and to evaluate the current system

in greater depth. For example, a number of system parameters are currently predefined, such as the contextualised summary sentence cap and the fixed selection of meta-data information. However, these parameters can be set experimentally with user studies, or potentially left to the user to specify dynamically.

Finally, we have demonstrated the techniques we have developed using the literature of one scientific discipline, that of biomedicine. We aim to also apply the techniques to other disciplines; we expect the transfer to other scientific domains to be straightforward, but the extent to which our approach can be used more broadly remains to be seen.

7. CONCLUSION

In this paper, we described a new research tool aimed at supporting researchers as they acquire knowledge through the perusal of scientific literature. The Citation-Sensitive In-Browser Summariser (CSIBS) was designed and developed by taking into account real tasks and information needs of academic researchers, particularly biomedical researchers. CSIBS helps readers determine whether or not a cited document is worth reading further, addressing issues of trustworthiness and citation justification. This is done by providing readers with documents enhanced with summaries. We evaluated CSIBS by presenting the resulting enhanced documents to three users, who indicated that the extracted summaries were useful for the relevance judgements. The approach naturally complements a document's own abstract, given that generated summaries can present detailed information from the body of the cited document that is more relevant to the specific citation context.

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