

Gist Summaries for Visually Impaired Surfers

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ABSTRACT

Anecdotal evidence suggests that Web document summaries provide the sighted reader with a basis for making decisions regarding the route to take within non-linear text; and additional research shows that sighted people use ‘Gist’ summaries as decision points to bolster their browsing behaviour. Other studies have found that visually impaired users are hindered in their cognition of the content of Web-pages because users must wait for an entire Web-page to be read before deciding on its usefulness to their current task. In these cases, we draw similarities between sighted and visually impaired users, in that sighted users cannot see the target of a Web Anchor and are therefore ‘handicapped’¹ by the technology. Previously, we have investigated four simple summarisation algorithms against each other and a manually created summary; producing empirical evidence as a formative evaluation. This evaluation concludes that users prefer simple automatically generated ‘gist’ summaries thereby reducing cognitive overload and increasing awareness of the focus of the Web-page under investigation. In this paper we focus on the development of ‘FireFox’ based tool which creates a summary of a Web page ‘on-the-fly’. The algorithm used to create this summary is based on the results of our formative evaluation which automatically and dynamically annotates Web pages with the generated ‘gist’ summary. In this way visually impaired users are supported in their decisions as the relevancy of the page at hand.

Categories and Subject Descriptors

H.1.2 [Models and Principles]: User/Machine Systems—*Human factors / Human information processing*;

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General Terms

Human Factors, Design, Measurement

Keywords

Document Engineering, Tools, Web, Visual Impairment

¹Handicapped (as in ‘hindrance’) *n.* : something immaterial that interferes with or delays action or progress.

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1. INTRODUCTION

Movement through and around complex hypermedia environments, of which the Web is the most obvious example, has long been considered an important and major issue in the Web² design and usability field [11, 18]. The commonly used slang phrase ‘surfing the Web’ implies rapid and free movement, pointing to its importance among designers and users alike. It has also been long established [6, 13] that this potentially complex and difficult movement is further complicated, and becomes neither rapid or free, if the user is visually impaired³. These problems are compounded if the user does not have context or preview information on which to base movement decisions. Previous work has suggested that both the context of the document and a preview of the document information should be considered when creating Web-pages [23, 22]. It has also been recognized in the hypermedia and ergonomics design communities that design patterns including context and preview may also be important [36, 21]. These patterns often take the form of manually created summarisations or complicated algorithmic summarisation whose main focus is the summary⁴ of linear documentation and so is less effective for non-linear texts [20, 31]. Anecdotal evidence suggests that Web-page summaries provide the reader with a basis for making decisions regarding the route to take within non-linear text. The summary will often contain information supporting context and preview of the target document; evidentially displayed on any ‘Google’ search. Theoretical work also exists on document summarisation however, this work normally ignores the user and focuses on the utilitarian [16]. Still other research supports the anecdotal design pattern view that uses benefit from small ‘Gist’⁵ summaries used as decision points⁶ within their browsing behaviour. In these cases, we draw similarities between sighted and visually impaired users, in that: (1) Sighted users interacting with small screen devices or traversing hypertext resources; (2) Users with low vision using screen magnification technology⁷; and (3) Profoundly blind users interacting via screen readers⁸. In these

²Or hypermedia.

³Here used as a general term encompassing the WHO definition of both profoundly blind and partially sighted individuals [2].

⁴Summarisation (as in ‘summary’) *n.* : brief account that presents the main points in a concise form

⁵Gist (as in ‘effect’) *n.* : the central meaning or theme of a speech or literary work.

⁶From graph theory: a point in a decision tree at which a set of attributes suggest a path along an arc.

⁷Screen magnification software enlarges the information on the screen by pre-determined incremental factor [for example, 1x magnification, 2x magnification, 3x magnification, etc.]. Magnification programs run simultaneously and seamlessly with the computer’s operating system and applications.

⁸Screen readers are special applications that vocalise the onscreen

cases we could say that all users (1 and 2) share commonalities with profoundly blind users (3) when their vision is handicapped by technology. Because the communication bandwidth from Web page to blind user is so much reduced compared with a sighted user that the information that is conveyed has to be exactly the information (no more and no less) that the user requires at that particular moment.

In this paper we focus on the development of Firefox based tool which creates a summary of a Web page ‘on-the-fly’. We wish to assist visually impaired users answer the question:

“Should I read this?”

The algorithm used to create this summary is based on the results of our formative evaluation which automatically and dynamically annotates Web pages with the generated ‘gist’ summary. In this way visually impaired users are supported in their decisions as to the relevancy of the page at hand.

1.1 Synopsis

Previously, we have investigated four simple summarisation algorithms against each other and a manually created summary; producing empirical evidence as a formative evaluation. This evaluation concludes that users prefer simple automatically generated ‘gist’ summaries thereby reducing cognitive overload and increasing awareness of the focus of the Web-page under investigation. We propose that these automatically generated ‘gist’ summaries are useful to both sighted and visually impaired users alike. In this paper we explain our system and rationale for creating these summaries; our argument and discussions proceed as follows:

Browsing A knowledge of browsing is important for any discussion regarding non-linear narratives. Here, we investigate the browsing behavior of Web users to support our assertion that summaries are often used as decision points and that these decision points are best in this context if they are small and simple.

Summarisation The challenge of automatically summarising Web pages and sites is a great one. However, currently there is no solution which offers an easy way to produce unbiased, coherent, and content full summaries of Web sites. We suggest that, for most users following a non-linear narrative, summaries are used not as a substitute for the hypermedia resource but as a decision point as to whether to access it. Here, we give an overview of summarisation techniques and present evidence that suggests readers use summaries as decision points into the main narrative. We also investigate information overloading and describe how too large a summary, all be it with excellent gist information, will have detrimental effects for the reader.

Formative Evaluation Here, we present the conclusions of our formative evaluation to investigate the quantity and accuracy of a summary used for decision making. Overall, our formative evaluation concludes that small accurate summaries with a low cognitive load are preferred over original or longer, more complex, summaries.

‘Summate’ – A Tool for Gist Summary Creation Our research concludes with the development a tool to create small simple summaries. This is a client-side system to automatically and dynamically annotate Web-pages with a small summary at its head to assist the user in the decision ‘Should I read this?’

data. Pages are typically read from the top left to the bottom right, one word at a time.

Wrap-up and Conclusions Finally, we focus on our conclusions from the work undertaken, summarise the work we have completed, and look forward to see how future work on automatic summarisation, using simple algorithms, will support access to visually impaired users.

2. BROWSING

It is recognised that, whilst browsing, users do not read Web pages, they scan them [34]. Summaries can be important elements of Web pages to facilitate scanning and browsing as well as a means of decision making if the summary is not part of the page it references. As a consequence we research browsing and scanning behavior to investigate our assertion that summaries are used as decision points in to a main body of text. The literature on scanning and browsing activities [8, 33, 14] suggest that preview (ergo summarisation) is not only involved in the activities, but is also necessary for its successful completion. If Web surfers did not use preview while browsing hypertext then it would be difficult to suggest that small succinct summaries would be useful for following non-linear narratives.

Browsing is an activity that is difficult to define [8], but there is general agreement that “we all browse in various contexts to make sense of the world around us” [9]. Some researchers also describe it as a process of “picking out bits and pieces... selecting worthwhile information need or interest” [14]. Different disciplines look at browsing from different perspectives [9]. Various reviews suggest that browsing is a kind of searching, in which initial search criteria or goals are only partly defined or known in advance. Browsing involves scanning, which has been described as looking, examining, or sampling, during which the person’s body or eyes move smoothly at will [34]. Browsing also involves distinct [9] consumer shopping behavior that is related but not equated with buying behavior. Methodologically, eye movement can be a useful indicator of browsing and has been used to test the effect of different page layout or catalogues on browsers’ attention [9]. Browsing is fundamentally scanning and has been related to environmental perception and cognition. For example, sightseeing is environmental browsing as perceptual experience [9].

Although all of these views of browsing have various approaches and provide different definitions, there seems to be an agreement on the essential characteristic of browsing which is movement. Browsing can be thought of as travel in information space, and in fact many users refer to real world metaphors to describe browsing [30]. Indeed research suggests [33, 26] that browsing is made up of *Searching*, the task of looking for a known target. *Inquiry*, the task of looking to see what is available in the world. *Querying*, using a search engine to submit a description of the object being sought and receiving relevant content of information. And *Navigation*, moving oneself sequentially around an environment, deciding at which step where to go.

In investigating the nature of browsing, several researchers have attempted to establish different types of browsing [26]. Fundamentally, these types have been established by considering the goal, purpose or the information need. Search strategies have been defined as “a set of ordered tactics or behavioral moves that are consciously selected, applied and monitored to solve the problem” [33]. Analytical search strategies are formal, discrete and deterministic, in contrast, browsing search strategies are informal, continuous and heuristic. Indeed the four distinguishable browsing strategies of scanning, observing, monitoring, and navigating have been identified [33]. Finally, five dimensions that can be used to distinguish browsing from other information seeking behaviors and to characterize types of browsing [9] have been suggested.

Context: Organisation (how resources are organised and presented), Interface (the display perceived by the user), Feedback (relevance or content related, and orientation feedback), Economics (access costs, resources available such as time).

Behavioral: Scanning (orientation or exploratory scanning) and movement.

Motivation: Purpose (why people engage in browsing) and goal (what they intend to accomplish).

Cognitive: Plan (accomplishing a goal can be planned or unplanned) and knowledge / experience (content or structure knowledge).

Resource: Form (object or representation) and focus (content or path) of resource.

These five views are important to our research because motivation influences context and summarisation supports context. Preview influences summary composition and supports behavior, and accurate but succinct information supports cognition and resource destination.

In summary, browsing is movement in the information space and the user is in control of what to read or examine. While chance or synchronicity may have some part to play in browsing behavior the user is still in control of the filtering the information presented. Many studies have addressed different browsing types and strategies [30] however movement is the essential characteristic of browsing [4]. We all browse in various contexts picking out bits and pieces of information and selecting worthwhile information [29]; and we accomplish this by using a searching and scanning behavior over organisations of the material [37, 34], interfaces to that material [3], and feedback about the material [33]; summaries used as decision points support all these behaviours.

3. SUMMARISATION

Being able to automatically summarise a Web-page into a brief and concise form is such a useful activity that many researchers have, or are, pursuing algorithms to generate accurate, concise, and comprehensive results. However, currently there are no solutions which offer an easy way to produce unbiased, coherent, and content full summaries of Web sites. We suggest that, for most users following a non-linear narrative, summaries are used not as a substitute for the hypermedia resource but as a decision point as to whether to access it.

3.1 Other Work

Automatic summarisation techniques have existed since the nineteen fifties. These techniques were initially created to summarise large amounts of spoken information of the kind found in transcripts of meetings, legal proceedings, and television broadcasts. They aimed to summarise large amounts of textual information into a more concise but complete form and were usually separated into ‘deep’ and ‘shallow’ techniques. Shallow techniques employed simple linguistic analyses of the information to rank terms, and groups of terms, into the most significant; so that phrases could be picked out and concatenated. Other ‘deeper’ algorithms have been formulated taking their cue from the artificial intelligence field and using knowledge-based methods for condensing information. While deeper methods based on natural language processing [38] and fractal summarisation [45] are still in development, attention is now switched much more to shallow methods for the rapid summarisation of online resources [31].

Broadly, these shallower techniques can be grouped as: (1) query

based summation; (2) link based summation; (3) text and media extraction; and (4) ‘Gist’ creation. Let us look at these in more detail.

Query Based Summation: Query based summation is of obvious importance to any discussion of Web based summarisation. This method summarises each page based on the keyword search set entered by the user. The method can be based on different algorithms such as: structural evaluations [1], task oriented approaches [41, 40], and text to alternate-media summations [44]. However, in all cases information around the target keyword is extracted and ordered into a semi-coherent statement. These methods have proved quite successful when evaluated within the context of direct task based tests [39]. Although these results are encouraging and support our research, work has not yet been undertaken with regard to the freeform browsing or non-linear resources.

Link Based Summation: The obvious question to ask when studying non-linear resources is how can it’s non-linear nature help us create summaries. The answer is to try and use hyperlinks as summary markers within the page content. It has already been shown that summaries of hypertext link targets are useful for user cognition [23], therefore, extending the technique may also be useful for summarisation. By using the context and content surrounding a link more efficiently-generated and complete summaries can be created [15]. These techniques have met with some success in their application however problems do exist because document summaries generated in this way rely on a profusion of associative and referential links. This is in opposition to the majority of Web-sites which forgo real hypertext structures for purely structural linking.

Text and Media Extraction: Text and media extraction techniques owe their origins to more conventional summarisation techniques but some do have twists to accommodate Web based resources. These include relevance measures, latent semantic analysis [20], and the retrieval of sentences that highly match a users browse requirements [42]. The use of other forms of media for summation is also prevalent using the extraction approach. These include the use of thumbnails for visual users [43] and the use of media similarity matching for combing both media and text [35]. While small bespoke studies have been performed these have, as with query based summation, not address the freeform browsing or non-linear resources.

‘Gist’ Creation: Certain techniques lay outside the conventional norm of document summarisation. These aim to address summarisation of documents but using different but related techniques. These can include the use of browsing histories to predict the summaries that should be created [12]; non extractive summarisation using translation techniques to re-group information into a more concise form [5]; and using the provision of tasks – questions – and concepts to assist the browser [32]. In general these techniques try to summarise the page into a a very small but concise form. Indeed their objective is to distil out the superfluous information and arrive at the gist of the page. A full and comprehensive summary is not required in many cases as gist summaries are intended to answer the question ‘Is the full text worth reading?’

3.2 The Accessibility Card

Accessibility⁹ is one key factor in summarisation because visually impaired people usually access Web pages by using screen readers such as Jaws [24]. Screen readers work well as long as the page is designed in a linear fashion, is not lengthy, and the most important information is triaged to the top. However, this is not normally the case, usually they are complex, nonlinear, and journalistic in their style of writing, with a focus on visual interaction. This means that summaries are of special interest to visually impaired people, and users of small screen devices, who can use them to gain a quick overview of the page. This allows decisions as to a page's importance to be taken [7].

3.3 Information Overload

Cognitive overload is a critical problem when navigating large information resources. This overload is increased if the narrative is non-linear and may switch context unexpectedly. Preview through summaries is key to improving the cognition of users in large heterogeneous resources but complex, comprehensive summaries can often overload the reader with extraneous information [17, 25]. People read text by using jerky eye movements (called Saccades) which then stop and fixate on a keyword for around 250 milliseconds. These fixations vary and last longer for more complex text, and are focussed on forward fixations with regressive (backward) fixations only occurring 10-15 percent of the time when reading becomes more difficult [27]. People, reading at speed by scanning for just appropriate information tend to fixate less often and for a shorter time, however, they can only remember the 'gist' of the information they have read; and are not able to give a comprehensive discourse on the information encountered. This means that comprehensive summaries for users quickly scanning (see Browsing Section) a narrative feature an increased amount of information that is not actually used in the decision making process of the reader. This information only adds to a users information overload, or perception of their overload [28]. Therefore, by creating small concise summaries we can support a readers natural scanning behaviour (when browsing or searching) and also reduce their cognitive overload by reducing the information they need to read.

4. FORMATIVE EVALUATION

The summarisation work discussed in the previous section suggests that small shallow summaries are useful as decision points into non-linear information sources. Our objective was to see if users benefit from such simply generated summaries by creating four different summation algorithms following the extraction techniques of the previous section and soliciting user responses. In each case we compare these techniques to an original manually generated summary in an effort to understand user cognition via a standard preference indicator. Remember, we are not concerned with finding which algorithm should be employed in the context of how comprehensive the summary is, but instead in the context of user preference - even if that means a less comprehensive summary but one that is more cognitively acceptable to users. The full results can be found elsewhere; but are summarised as follows:

- Our formative evaluation supports the anecdotal design pattern view that uses benefit from small summaries used as decision points.
- We find that a small summary taking the first sentence of each paragraph is optimal.

⁹Ergo, Visual Impairment.

- Results suggest that information overload is as dis-empowering as 'information under-load'.
- Our statistical analysis suggests that there should be a maximum limit placed on generated summaries of between 4 and 6 sentences depending on the function of the summary. However, 4 sentences were found to be optimum.
- User comments suggest that the summary should be emphasised by prominently displaying the text.

42 individuals participated in our evaluation; 21 male and 21 female; with 7 male and 7 female for each age range category of: 16-30, 31-45, and 46-60. A spread of occupations were targeted. Using our base set we get an 80% Confidence Interval with a Sampling Error Rate of (+/-)10% for a population of 150,000 [10]. Respondents were asked to comment on a simple question using a variant of the NASA Bi-Polar method and a bivariate scale [19]. Our results show a strong leaning toward our summary algorithm which picks one sentence from the start of each paragraph as being the readers most preferred choice. This preference was supported as results indicated that most users rated their preference as 'Strong' (+4) in favour of this summary. An analysis of the variance over each article¹⁰ shows that users preference is again supported regardless of the article they have been shown.

5. 'SUMMATE'

'Summate'¹¹ is our tool¹² for gist summary creation which supports our formative evaluation findings. This is a client-side system to automatically and dynamically annotate Web-pages with a small summary within a modal 'alert box' to assist the user in the decision 'Should I read this page?'

The Summate application aims to enable the user to generate a fast short summary to assist them in informed traversal of the non-linear environment. Summate, is a Firefox¹³ extension¹⁴ which overlays the Firefox 'Tool' menu and enables summaries to be created (see Fig. 1 at 'A'). The generated summary is displayed in a pop-up which relies on Firefox and associated screen reading technologies to be able to communicate. Failing this, our algorithm is freely available for porting onto other Web browsers.

5.1 How Do We Create A Summary?

Our tool parses the XHTML¹⁵ DOM¹⁶ and attempts to cull the first sentence of each paragraph from the returned model. A maximum of 4 sentences are used: the first, the first sentence of the last paragraph, and the sentence laying at the upper (75%) and lower (25%) quartiles. Full quotations are taken as being atomic in that if those quotations have multiple sentences they are included as one. Finally, an informal measure of the 'goodness' of the summary is

¹⁰We tested over 4 different articles presented in a random order to minimise memory effect.

¹¹Summate (as in "combine") v. : form or constitute a cumulative effect.

¹²Downloadable from <http://augmented.man.ac.uk/summate/>

¹³Web browser - <http://www.mozilla.org>.

¹⁴Extensions allow programmers to add new features to Firefox applications or allow existing features to be modified. Typically, extensions modify the 'chrome' of their target application - the user interface and the scripts that add functionality to that interface. However, it is also possible for extensions to include compiled code in the form of XPCOM components.

¹⁵Extensible Hypertext Mark-up Language.

¹⁶Document Object Model.

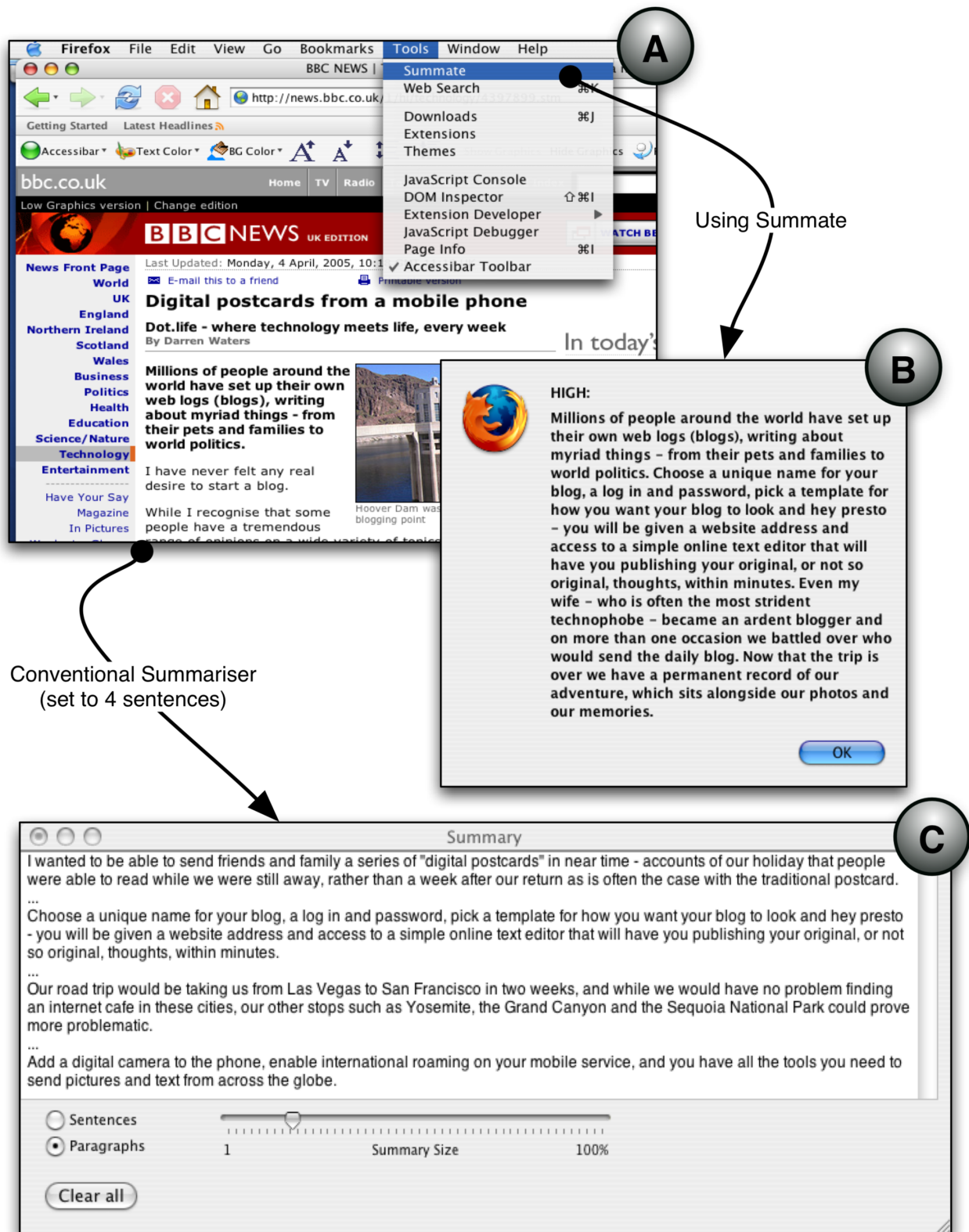


Figure 1: Summate in use; here we summarise a BBC News article on the subject of 'Digital Post Cards from a Mobile Phone' (<http://news.bbc.co.uk/1/hi/technology/4397899.stm>)

added by placing the denotation: HIGH, MEDIUM, or LOW at the head of the summary. This measure is derived by analysing the number of sentences returned; the rationale is that if only one sentence is returned it is likely the whole summary will be less expressive than a summary with four sentences returned. The summary is then displayed as a JavaScript generated FireFox alert (see Fig. 1 at 'B'). Our refined algorithm, shown here in pseudo code, is both simple and effective:

```

FUNCTION
IF we encounter a DOM.textnode THEN
    grab the DOM.text
    strip white-space from the start
    IF the text length is > 70 THEN
        find the position of any closing quotes
        set the end position to the closing...
            ...quote OR 0 if no quotes
        find the end of the sentence (!, ?, .)
        return the sentence
    ELSE
        return 'undefined' / null
    ENDIF
ELSE
    REPEAT
        recurs this function
        IF returned value is not undefined
            add returned sentence to sentence-array
        ENDIF
    UNTIL no DOM.children left

    COMMENT
        Due to the recursion the next section
        will happen only last and only once
    ENDCOMMENT
    IF sentence-array > 4 THEN
        find bottom quartile sentence
        find top quartile sentence
        OUTPUT goodness measure = 'HIGH' +
            first sentence + bottom quartile +
            top quartile + first sentence...
            ...(last para)
    ELSE
        LOOP through joining sentences from array
        add goodness measure based on...
            ...loop iterations
            1 iteration = LOW
            2 iterations = LOW
            3 iterations = MEDIUM
            4 iterations = HIGH
        OUTPUT joined sentences
    ENDIF
ENDFUNCTION

```

5.2 Analysis

In general the algorithm works quite well however some problems do still exist. We found that when summarising some pages, for example CNN (<http://www.cnn.com/2005/LAW/03/31/terror.suspect.arrest/index.html>), the summary can have small amounts of extraneous information present; which in this case means the summary is prefixed by:

"Payday loan cash in your account overnight."

Pages that are comprised of summaries such as the BBC News site (<http://news.bbc.co.uk/>) provide disjoint Summate summaries:

"Tony Blair, Michael Howard and Charles Kennedy have their only face-to-face clash of the election campaign. Thousands of Catholics from around the world are heading to Rome before Friday's funeral of Pope John Paul II. Monaco's Prince Rainier, Europe's longest-reigning monarch, dies at the age of 81, after a long illness. How a family with a pre-pay meter got a 38,000 electricity bill."

However, as the example above illustrates, these can still be quite descriptive. Summate also does not work very well with the front page of Weblogs¹⁷ (for example <http://wilwheaton.net/>) because these pages contain several disjoint full texts the summary is often too fragmented to make any sense. Finally, we have no frame support in traversal.

While all this is true we still assert that this is a good and appropriate start. Certainly the Weblog problem can be overcome with modifications to our algorithm. The addition of superfluous text (normally advertising) is more difficult to solve and on this case we rely on the content creators placing adverts in XHTML <advertisement> elements.

5.3 Summative (Re) Evaluation

To test our implementation we performed some informal evaluations by presenting a Summate created summary (see Fig. 1 at 'B') and a summary created by a conventional summariser (see Fig 1 at 'C') to a set of volunteer testers. We choose six sighted users and read each summary along with the full article to each. The only requirements were that they had experience in using the World Wide Web, that they each surfed different kinds of Websites (not just news, say) and their first language was English or they were fluent in reading English (although their fluency was not formally tested and we relied on their honesty). All testers followed a set script and the whole process was initially tested on two respondents as a way of eliciting comments on the procedure.

We choose random Web-sites but categorised each page tested as: (1) Stand-alone; (2) Summary Page; (3) Mixed Context. We then tested a series of pages and asked users to respond with the summary they preferred (See results at Table 1). As can be seen from our results, users on the whole preferred Summate summaries against conventionally generated ones. Indeed, even were we thought that the conventional summary generator created better results than Summate our respondents preferred Summate as they understood the gist faster. They could therefore infer the content, and in some cases the switching of contexts, of pages more easily.

6. CONCLUSION

We have drawn parallels between the interaction needs of sighted and visually impaired users when: (1) Sighted users interacting with small screen devices or traversing hypertext resources; (2) Users with low vision using screen magnification technology; and (3) Profoundly blind users interacting via screen readers. In these cases we could say that these users (1 and 2) share commonalities with profoundly blind users (3) when their vision is handicapped by technology.

This is because the communication bandwidth from Web page to

¹⁷Weblog, Web log or simply a blog, is a Web application which contains periodic time-stamped posts on a common Webpage often but not necessarily in reverse chronological order.

Table 1: Informal Summative (Re) Evaluation Results

Page	Cat.	S	C
http://news.bbc.co.uk/1/hi/technology/4397899.stm	1	6	0
http://www.cnn.com/2005/LAW/03/31/terror.suspect.arrest/index.html/	1	5	1
http://hitokyo.blogspot.com/2004/11/japanese-food-rocks.html	1	5	1
http://news.bbc.co.uk/	2	6	0
http://www.cnn.com/	2	4	2
http://www.manchester.ac.uk/	2	2	4
http://wilwheaton.net/	3	3	3
http://www.theatlantic.com/	3	4	2
http://www.amazon.co.uk/	3	5	1

Number in column **S** denotes users who preferred **Summate** summaries. Number in column **C** denotes users who preferred **Conventional** summaries. Number in column **Cat** denotes: (1) Stand-alone; (2) Summary Page; (3) Mixed Context.

blind user is so much reduced compared with a sighted user that the information that is conveyed has to be exactly the information (no more and no less) that the user requires at that particular moment.

In accordance with these similarities we have described the design and implementation of a tool for creating dynamically generating Gist summaries based on our formative evaluation. Through this study we confirmed that small summaries were important for browsing by all Web users and designed our tool to implement these findings. We propose that further work needs to be undertaken along 2 paths: (1) extension of the system such that the problems of incorrect summaries, information overload, and clutter in the docuverse are overcome; and (2) the creation of a formal (and therefore more rigorous) summative evaluation to confirm our implementation.

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