Adjusting Windows: Balancing Information Awareness with Intrusion

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ABSTRACT

The World Wide Web has quickly become a primary source of information for a variety of real-time topics, such as news headlines, stock market data, sports scores, and weather forecasts. However, achieving a high degree of awareness for this real-time information is particularly challenging as users are often performing other necessary tasks. As a result, techniques for notifying users of new or updated information must do so in a manner that is both timely and non-intrusive to their current task. In this paper we propose a new awareness technique, called Adjusting Windows, suitable for informing users of updated information on real-time information sites. The technique has been fully implemented within a new web browser application. We conducted a small user study in order to compare Adjusting Windows against two other awareness techniques in terms of awareness time, awareness strategy, and overall preference. Analysis of the data demonstrated that Adjusting Windows provided the best balance of information awareness with intrusion, and was preferred by many of the users.

KEYWORDS

Adjusting Windows, Awareness Strategy, Information Awareness, Interruptions, Intrusion

1. INTRODUCTION

The World Wide Web has become a primary source for real-time information, such as news headlines, stock market data, weather reports, and sports scores, for millions of desktop users around the world [6]. For purposes of this paper, we collectively refer to these types of web sites as real-time information sites. Whenever new or updated information is added to these real-time sites, the interested user must somehow be made cognitively aware that this new information is now available for consumption.

We define *information awareness* as the amount of time between the availability of new information and the time at which the user acknowledges or consumes this information. However, interested users are probably not browsing the site at the exact time an information update occurs; rather, they are busy performing other tasks. As a result, interface techniques designed to achieve a high degree of information awareness must attract user attention away from the task at hand. At the same time, these awareness techniques must not be perceived as overly intrusive or they will ultimately be rejected.

We define *intrusion* as the property of an information awareness technique that increases user annoyance, disrupts task performance, or both. An awareness technique with high intrusion would have a large negative effect on user annoyance or task performance, whereas a technique with low intrusion would have a small negative effect. An unwarranted popup ad appearing while a user is navigating the Web is an example of an intrusive awareness technique.

This paper addresses the problem of notifying users of updated real-time information in a manner that simultaneously achieves high information awareness with low intrusion. We assume that this real-time information regards a topic that the user has previously expressed an interest in receiving, perhaps by selecting from among several choices at their favorite web portal site. This assumption is not unrealistic as several portal sites, such as CBS MarketWatch, ABC News, and MSNBC News, support this functionality.

To achieve high information awareness with low intrusion, we have developed a new awareness technique, called *Adjusting Windows*, adapted from the shrinking window technique commonly used by television broadcasters. The technique allows information to be visible "at a glance" without supplanting the current task or forcing the user to switch between application windows. For the remainder of this paper, we use the term *information event* to refer to an instance of real-time information that must be presented to the user.

2. RELATED WORK

In his work on autonomous interface agents, Lieberman [4] notes that agent feedback must not disrupt the normal workflow of the user. Thus, his interface agent did not attempt to attract the user's attention away from the current task. The recommended information was simply placed in a separate window where the user could glance whenever it was convenient during the browsing session. However, this companion window not only takes up valuable screen space, but since no attempt is made to attract the user's attention, many of the recommendations may go unnoticed.

Maes [5] describes how an agent can use facial expressions to inform the user "at a glance" about its internal state. Although non-intrusive, this technique is only plausible when a small number of states need to be represented. In our work, we need to move beyond a simple icon change in order to provide the user with some hint as to the information content. Otherwise, new information can easily be ignored or go unchecked.

Several user interface techniques and technologies have also been used to balance high awareness with low intrusion. User interface designers may choose among at least four possible solutions:

- *Dialog window*. A non-modal dialog window that appears whenever an information event needs to be displayed. Examples are the popup ads one often encounters while navigating the Web.
- *Dynamic HTML page*. An HTML page that is dynamically generated each time the user navigates to that page or is automatically refreshed every few minutes. An example is a personalized Microsoft Network home page.
- *Small background window*. A lightweight desktop application utilizing a small toplevel window (~200 x 350 pixels), possibly written in Java and launched the first time a user navigates to the site. When new or updated information is added to the site, it is then pushed from the site to the user's desktop, and displayed in this window. Examples are the small, configurable news windows provided by PointCast [7] as well as the MSNBC and ABC news sites.
- *System tray event*. Under Windows, an application can display a static or flashing icon in the lower right hand corner of the task bar in order to alert the user of new information. An example is Netscape's mail notification icon.

Although these techniques may be useful at times, they are generally either too intrusive or provide only a low degree of information awareness for the user as summarized in Figure 1.

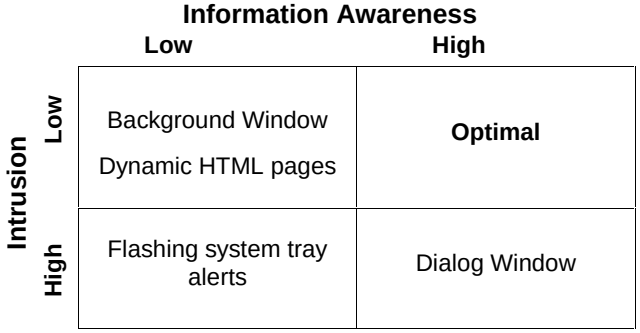

Figure 1: Summary of user interface techniques commonly used to notify users of new or updated information on real-time web sites. Current techniques achieve either high awareness or low intrusion, but not both.

What is needed is a new awareness technique that simultaneously achieves high information awareness with low intrusion for the user. To satisfy this dual constraint, we have adapted a technique from television broadcasters that we call *Adjusting Windows*.

3. ADJUSTING WINDOWS

We have implemented a new web browser, called the Adjusting Windows Browser (AWB), written entirely in the Java language. The AWB adapts the shrinking window technique commonly used in television broadcasts for informing users of significant or periodic real-time information events. Although this technique could have been implemented in any number of applications, we chose to implement it within the context of a web browser for several reasons. First, the web browser is one of the most widely used applications today and finding test users who are familiar with browsing the Web and performing web-related tasks would not be hard. Second, because we are assuming that the information sources are real-time web sites, a web browser seemed like a natural application choice.

3.1 AWB Behavior

When a new information event is received by the AWB, the main viewing window slightly shrinks in an animated fashion, and the new information is wrapped along the side and bottom of the window (see Figure 2). Just prior to the main window animation, a short musical tone is also played in order to pre-inform the user of the incoming information (if preferred, this tone can be disabled). The entire animation is very quick and lasts only for a few seconds. In an earlier attempt, we adjusted the window size without the animation, but the sudden jump in size was very distracting. The short animation is much less disruptive and helps alert the user to the incoming information based on principles of attentional focus [2]. The main viewing window remains in this adjusted state until either the user presses the ESC key or until a user-definable time period elapses, whichever comes first. Once either occurs, the information event disappears and the main window animates back to its original size. In the current implementation, the contents of the browser are not scaled as in [1,3].

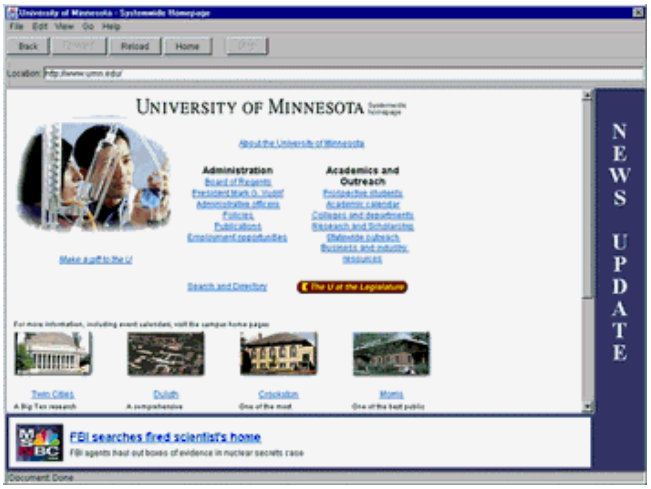

Figure 2. The AWB presents information events to the user by first shrinking the main window area and then wrapping the information along the side and bottom of the window.

3.2 Information Events

Each information event is sent in the form of an HTML file from a simulated portal site to the AWB, and thus can contain any number of text, images, or hypertext links. The ability to place hypertext links in the information event is particularly useful because if the user wants additional details, they can simply select the link and navigate directly to the detailed information. The only limiting factor of the information display is in the width

and height of the space allotted to the interruption panel (~100 pixels high x the width of the main viewing window). This amount of space was decided upon by trial and error where the goal was to provide the smallest amount of screen space in which an adequate amount of information could be displayed.

3.3 Balancing Information Awareness with Low Intrusion

Because the information event is displayed in the browser window without supplanting the current task or forcing the user to switch windows, a low level of intrusion is achieved. In addition, the user decides whether to immediately suspend or finish the current task before attending to the information event. As a result, the user can effectively achieve varying degrees of information awareness. In sum, the adjusting window allows the user to balance varying degrees of information awareness with low intrusion. To test these claims, we conducted a small user study comparing our adjusting window technique against both a small background window and a dialog window for displaying information events. The details and results of this study are presented next.

4. USER STUDY – A COMPARISON OF THREE AWARENESS TECHNIQUES

The user study provides both a quantitative and qualitative comparison between the adjusting window and two other commonly used information awareness techniques; a background window and a dialog window. The quantitative analysis compares awareness time; i.e., the amount of time an information event is available before the user acknowledges it in the midst of performing a task. The qualitative analysis measures both user preference and annoyance level for each awareness technique.

4.1 Experimental Design

Subjects were asked to perform a set of tasks drawn from several different categories. While performing each task, subjects were presented with an information event using one of the three awareness techniques. Subjects were free to acknowledge the information event whenever it was convenient for them during the task. This acknowledgement time was recorded as well as the subject's response behavior to the information event. The task categories, information events, and awareness techniques used within the experiment are described next.

4.1.1 Task Categories

In order to promote different attention and concentration levels, five different task categories were used:

- *Addition*. Four numbers representing the purchase price of an item along with its tax, commission, and shipping charge were presented to the subject. The task was to correctly add up the numbers and enter the total amount into a text field.
- *Counting*. An unordered list of several items was presented to the subject. The task was to count the number of items in the list that correctly matched a given criteria and then to enter this number into a text field.
- *Reading Comprehension*. A short passage (~4-5 sentences) was presented to the subject. The task was to read the passage and then correctly answer two questions regarding its content.
- *Registration*. Three registration-style questions were presented to the subject; e.g., age range, gender, and work phone. The task was to enter the requested information.
- *Selection*. Thirty checkbox items, representing names of digital camera manufacturers, were presented to the subject. The task was to select the camera manufacturers matching a given manufacturer name.

Because subjects performed more than one task from each category, multiple sets of similar tasks were designed. The tasks were implemented using HTML.

4.1.2 Information Events

Information events consisted of a title phrase as well as one or two sentences regarding news, sports, weather, or stock information. This information was selected from existing web sites in order to make the simulation as real as possible. The information events were also implemented using HTML.

4.1.3 Awareness Techniques

During each task, the subject was presented with a single information event using one of three different awareness techniques:

- *Dialog Window*. A non-modal dialog window was used to display each new information event.
- *Background Window*. A small, slightly obscured background window was used to display each new information event. The window was slightly obscured to reflect a realistic desktop interface.
- *Adjusting Window*. The main window of the browser was adjusted for each new information event. The information was displayed along the side and bottom of the window as described in Section 3.

In order to provide a consistent interface throughout the experiment, the AWB was modified to support both the dialog and background window techniques.

4.2 Subjects

8 subjects, 5 males and 3 females, volunteered to be a part of this user study and were not compensated for their effort. Each subject was currently enrolled as an undergraduate or graduate student at the University of Minnesota. All subjects were right-handed with corrected or normal vision.

4.3 Hardware/Software

The experiment took place on a Pentium II 300 MHz machine with 128 MB RAM running Windows NT 4.0. The tasks and information events were stored locally on the machine to avoid network variability and were rendered using the AWB. Each subject's screen interaction was recorded using Lotus ScreenCam.

4.4 Procedure

Subjects were asked to complete 4 experimental trials where each trial consisted of 5 tasks, one from each of the task categories defined above. Each of three trials involved one of the awareness techniques and the fourth trial was a control; i.e., the subject completed one task from each category without being interrupted. The experimenter emphasized to the subject that the tasks were being timed and that they needed to *complete each task as quickly as possible while still maintaining accuracy on the task*. Before beginning the experimental trials, subjects performed a practice trial without interruptions in order to familiarize themselves with the different task categories.

While performing tasks in the non-control trials, an information event was presented to the subjects at a pre-defined time based on the task category. The subject was instructed to read the presented information event *whenever convenient* during the current task and then to press the ESC key to dismiss it. Each task was interrupted only once and the awareness technique itself remained the same for the duration of the trial. The presentation order of the trials (awareness techniques), tasks, and information events were randomized to minimize bias. However, subjects were informed of which awareness technique was going to be used in the current trial.

At the end of each trial the subject was asked to select which 5 information events were presented in order to verify that they actually read them. The 5 actual information events were randomly ordered along with 5 distracters. After the four experimental trials were completed, the subject was asked to fill out a questionnaire. The entire experimental procedure took less than 60 minutes for each subject to complete.

4.5 Measurements

The experiment was designed to measure both information awareness and intrusion. To measure awareness the AWB was instrumented to record the amount of time from which the information event was initially presented to the time at which the user acknowledged (dismissed) it by hitting the ESC key.

Intrusion was measured in two ways; categorizing each subject's response behavior to the display of an information event and the post-experiment questionnaire. Response behavior was categorized according to the subject's awareness strategy. We define *awareness strategy* as the subject's behavioral response to receiving an information event while performing a task. Two awareness strategies were used:

- *Read Now*. Suspending the current task in order to read the presented information event and then resuming the previously suspended task.
- *Read Later*. Completing the current task first and then reading the presented information event.

After completing the experiment, each subject was asked to fill out a questionnaire. The questionnaire asked each subject to rate the:

- *Distraction level of each awareness technique*. Valid responses were Very Distracting, Somewhat Distracting, Not Distracting, or Don't Know.
- *Annoyance level of being interrupted for each task category*. Valid responses were Highly Disruptive, Mildly Disruptive, Not Disruptive, or Don't Know.
- *Difficulty level of each task category*. Valid responses were Hardest, Next Hardest, Middle, Next Easiest, or Easiest.
- *Preference for receiving information events using each awareness technique*. Valid responses were Favorite, Second Favorite, Third Favorite, or Least Favorite.

5. ANALYSIS

This section presents an analysis of the awareness measurements, response behaviors, and questionnaires.

5.1 Information Awareness and Awareness Strategy

The awareness data consisted of 120 (8 subjects x 3 trials x 5 tasks) recorded measurements. The data was analyzed using a 3 x 5 two-way ANOVA with task category and awareness technique as factors. Figure 3 displays a graph of the awareness time as a function of task category and awareness technique.

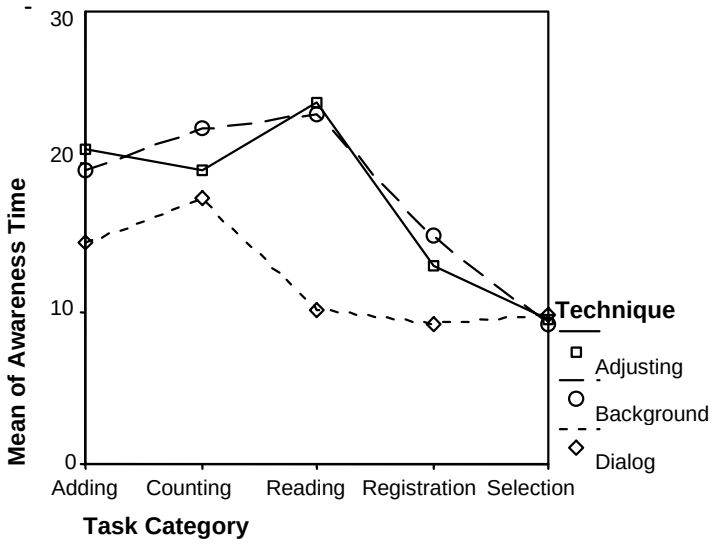

Figure 3. Awareness time as a function of awareness technique and task category. The Dialog achieved the highest degree of awareness across all tasks while the Adjusting and Background techniques were almost identical.

A main effect of awareness technique was present in the data ($F(2,105)=3.712$, $p=.03$). Further analysis concluded that this main effect resulted from the dialog technique only and did not exist between the background and adjusting window techniques. This result seems reasonable as one would expect the intrusiveness of the dialog to lead to a smaller awareness time. However, the small difference between the background and adjusting window

was somewhat surprising as we expected the adjusting window to resemble the dialog more than the background window. Reviewing the recorded interactions helped to explain this result.

For the tasks performed with the background and adjusting window, subjects employed the Read Later awareness strategy a majority of the time; 96% and 82% respectively. For the dialog window, subjects employed the Read Later strategy for only 26% of the tasks[1]. These results indicate that as the level of intrusion decreases, subjects are more likely to finish their current task first before attending to the information event. Hence, the similar low intrusion of the background and adjusting window resulted in similar awareness times, whereas the high intrusion of the dialog window led to a significantly lower awareness time.

A main effect of task category ($F(4,105)=4.260$, $p<.01$) was also present in the awareness data, but because the awareness strategies did not differ by category, this effect can be attributed to inherent performance differences among the task categories. By definition, longer tasks will have larger awareness times than shorter tasks when an equal number of Read Later strategies are employed. This explains the parallel decrease in awareness times for the background and adjusting window shown in Figure 3.

5.2 Questionnaire Results

The responses regarding the distraction level of each awareness technique are summarized in Figure 4a. Subjects unanimously rated the dialog window as the most distracting (intrusive) awareness technique. Subjects were evenly split between Not Distracting and Somewhat Distracting for the background window. And a majority of the subjects rated the adjusting window as Somewhat Distracting. Thus, the adjusting window is more distracting than a background window, but less distracting than a dialog window.

The responses regarding the difficulty level of each task category as well as how annoying it was to be interrupted (presented with an information event) during that task category are summarized in Figure 4b. Subjects found registration and selection to be the easiest tasks, while adding, counting, and reading were found to be the hardest tasks respectively. A linear relationship between task difficulty and interruption annoyance also appears from the summary graph. Subjects clearly state that the most difficult tasks were the most annoying to have interrupted, and vice versa.

The responses for overall preference regarding each awareness technique are summarized in Figure 4c. Subjects unanimously rated the dialog as being their Least Favorite awareness technique. The adjusting window and background window awareness techniques were rated similarly, but the adjusting window had the most Favorite ratings.

6. DISCUSSION AND FUTURE WORK

After carefully inspecting the results of the user study, we feel that Adjusting Windows positively addressed our research challenge of balancing information awareness with intrusion. Specifically, the user study found that the adjusting window technique was:

- *Between the dialog and background window in terms of intrusion.* Subjects rated the adjusting window as slightly more distracting than the background window, but far less distracting than the dialog window. In addition, subjects employed the Read Later awareness strategy more often than for the dialog window, but less often than for the background window. Together, these results suggest that the adjusting window had an intermediate level of intrusion, but not enough to demand immediate attention or supplant the current task.
- *Between the dialog and background window in terms of information awareness.* The adjusting window facilitated significantly more Read Nows than the background window, but far less than the dialog window. Although Figure 3 indicates that the background and adjusting window had similar awareness times across the task categories, this may have been due to slight variations in task performance. These variations may have been enough to contradict the qualitative measurements. Nonetheless, the qualitative measurements do indicate that the adjusting window provided an intermediate level of information awareness.

[1] Pairwise differences of the awareness strategy counts are significant (α =.05) assuming each count is an independent binomial random variable with p=.5.

- *Preferred by many of the subjects.* As shown in Figure 4c, the adjusting window received the highest number of Favorite votes. Because user preference is such a critical factor in user interface design, this result carries a great deal of weight. In fact, after the experiment was over, several of the subjects complimented the technique on how familiar of an idiom it was for them.

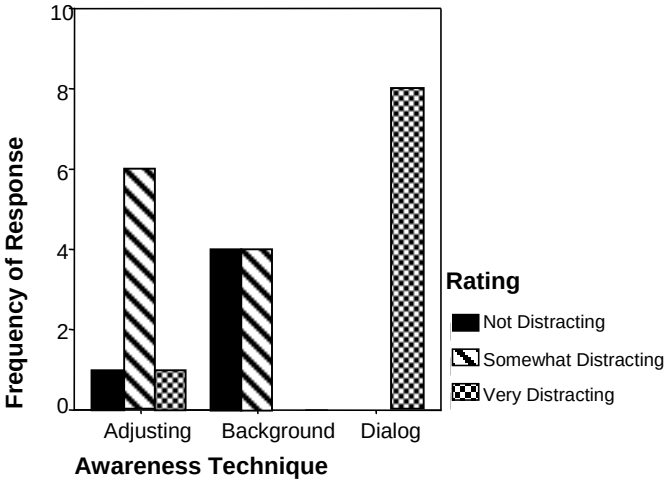

Figure 4a. Summary of distraction ratings for each awareness technique.

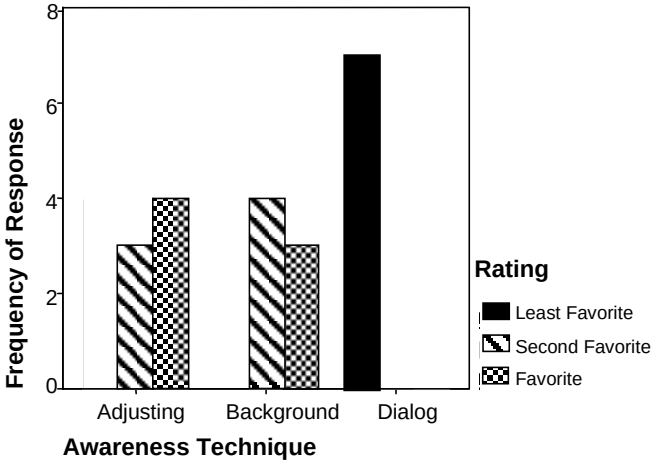

Figure 4c. Summary of preference ratings for each awareness technique.

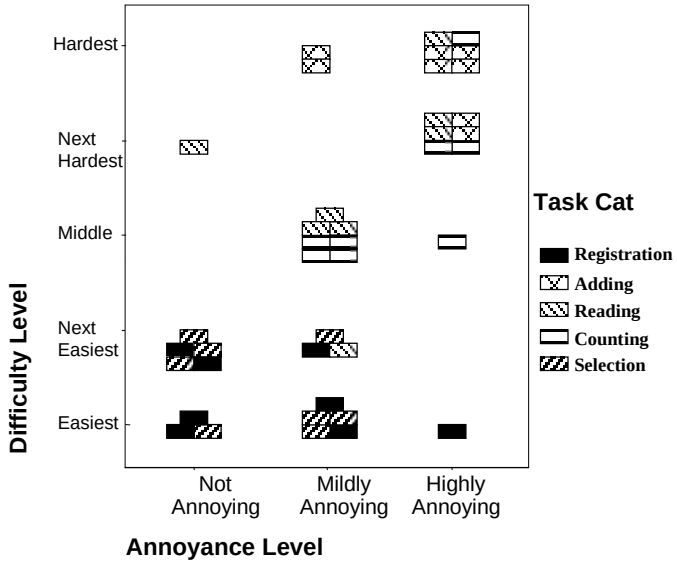

Figure 4b. Summary of Annoyance Level vs Difficulty Level for each task category. The graph shows that the most difficult tasks were Adding and Counting while the easiest tasks were Registration and Selection, with Reading somewhere inbetween. Interestingly, the more difficult the task, the more annoying it was to be interrupted during the task, and vice versa.

From the analysis, the primary drawback to the adjusting window was that the quantitative measure of information awareness was not significantly greater than the background window (see Figure 3). Although this may have been due to variations in task performance, we believe that an adjusting window is still superior to a

background window along several other dimensions. Background windows take up valuable screen space, are easy to ignore, and are often buried under other application windows, whereas an adjusting window only temporarily takes up screen space, provides information at a glance, and does not require window switching in order to view information events.

We also recognize that Adjusting Windows is not a panacea for user notification in all circumstances. If a high degree of information awareness is the primary goal, then dialog windows are still the better choice. If a low degree of intrusion is the primary goal, then background windows are still the better choice. However, when information awareness and intrusion need to be balanced, then Adjusting Windows has been shown to be the better choice.

Interrupting the user while actively engaged in a task is an area of research that deserves further attention from the user interface and HCI communities. Specifically, we see the following opportunities for future work:

- *Exploring the temporal aspect of information events.* The experimental results suggest that manipulating the temporal aspect of information events may also prove an effective method for balancing information awareness with intrusion. By withholding the display of information until task boundaries or periods of low interaction are observed, the user may still achieve the same awareness but with less annoyance.
- *Courteous interface agents.* Interface agents that need to notify users of decisions made or to solicit input from users should respect the difficulty level of the current user task. This work demonstrates that users are more annoyed when interrupted during difficult tasks than they are when interrupted during easier tasks. Thus, developing a set of task categories appropriate for the user interface, determining when each type of task is being performed by the user, and applying a set of rules for courteous interruptions, are all interesting problems for interface agent research.

7. REFERENCES

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