

USER BEHAVIOR UNDER THE MICROSCOPE

Can the Behavior Indicate a Web User's Task?

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Abstract: The automatic recognition of a user's current task by the surfing behavior requires detailed knowledge of the relationship between task and behavior. An exploratory study was conducted where 20 participants performed exercises on a given Web site. These exercises corresponded to the predefined user tasks Fact Finding, Information Gathering and Just Browsing following present research on user activities. The resulting behavior was recorded in detailed event log files which contain every action performed in the browser, such as mouse moves and clicks, scrolling, the use of the back button etc. The analysis of variance indicates that the three tasks can be differentiated with a combination of selected behavioral attributes.

1 INTRODUCTION

Recognizing the user's current task only by the behavior is an ambitious objective. If a user's task was known, various ways of support could be achieved. Present personalization mechanisms, e.g. recommender systems such as Amazon's, work on the basis of long term user behavior and information explicitly given, like product evaluations and purchases (Linden et al., 2003). They do not take into consideration the user's current needs, e.g. if the user is looking something up quickly or just searching for entertainment, or if the person intends to collect information about a topic. This knowledge could improve the quality of many personalization mechanisms such as link suggestions.

The problem is that not every little bit of the behavior, but only a selection of behavioral attributes, is crucial in identifying the user's task. An exploratory study was conducted to determine which attributes may be suitable for task recognition. Two aspects of the study must be particularly emphasized:

First, the task is always known in the experiment and, thus, represents the independent variable. The behavior, in contrast, is considered dependent on the task. This way, the participants' intentions are always known and the relationship between task and behavior can be scrutinized. In later practice, the direction will naturally be reverse with the user task being deduced from the behavior.

Second, the behavior is recorded in form of a detailed log containing every action processed in the Web browser, like mouse clicks, scroll moves, the usage of single pages, tabs and even browser buttons and menus. This allows various evaluations on the data which go beyond plain click stream analyses, like (Das et al., 2007) and (Géry and Haddad, 2003).

The procedure of the study is based on three user tasks following recent publications in this field such as (Kellar et al., 2006): Fact Finding, Information Gathering and Just Browsing. First evaluations on the collected data indicate that there exist significant differences between these tasks with regard to the overall duration of a task, the average time a user was looking at a page and the number of pages the user has looked at per minute. As the experiment was conducted on the Web site of an on-line newspaper, also specific attributes of the behavior, like the number of news categories visited, were investigated, which also revealed significant differences between the tasks.

The paper is structured as follows: In the next section the state of the art concerning user task taxonomies and task recognition is presented. Afterwards, the exploratory study is described followed by first results of the analysis of variance and t-tests. At the end a summary is given.

2 USER TASKS AND THEIR RECOGNITION

The first step towards user task identification is the definition of user tasks and bringing them into a taxonomy. Then it is possible to look for ways of recognizing the tasks.

In the field of discovering user needs, several branches have evolved. One branch deals with Web search, where search engine queries are assigned to certain goals which can be interpreted as user tasks. (Broder, 2002) formulated three groups of information needs in the context of Web queries: *navigational* (searching for a particular Web site), *informational* (searching for information about a topic, one site is not sufficient) and *transactional* (finding sites that enable transactions like shopping or downloads). (Rose and Levinson, 2004) arrived at a similar taxonomy, only *transactional* was replaced by a more general task, *resource*, comprising the subtasks *obtain, download, entertain* and *interact*. Both (Broder, 2002) and (Rose and Levinson, 2004) do not yet provide an approach to automatic task identification, but reinforce their taxonomies by manual classifications. An approach to identifying tasks is to be found in (Lee et al., 2005), where only the matching tasks of (Broder, 2002) and (Rose and Levinson, 2004), navigational and informational, are considered. Using the features *click distribution* and *anchor-link distribution*, good classification results were achieved with a rate of 80% or more correct classifications, and 90% when both features were used in combination.

Another branch regarding user tasks deals with general user activities on the Web. An early suggestion for a user task taxonomy was introduced in (Byrne et al., 1999). The activities they describe belong to a rather low level of abstraction, i.e. they define tasks like Locate (searching for something on a Web page, like a word or a picture), Go To (looking for a certain Web page), or Configure (changing the state of the browser, e.g. through scrolling). More suggestions of user task taxonomies at higher levels of abstraction followed, like (Choo et al., 2000; Morrison et al., 2001; Sellen et al., 2002). (Kellar et al., 2006) merged these three approaches and included findings from their own studies. The resulting taxonomy is described as follows:

- **Fact Finding:** The users have an exact target in mind, they are looking for a keyword, a date or a sentence. Activities belonging to this category are usually of short duration.
- **Information Gathering:** The users are searching for information on a topic, thus, the target is more

open, while still being restricted by the topic. Information Gathering usually takes more time and need not be completed within one session.

- **Just Browsing:** The users surf through the Internet as they like and with no particular target in mind. Activities like these may also be of longer duration.
- **Transaction:** The users want to perform transactions like on-line banking or checking their e-mails on-line.
- **Other:** This category comprises all activities which cannot be assigned to any of the other four categories.

Based on this taxonomy, an attempt of automatic task identification was made using classification. In a study, (Kellar et al., 2006) collected log data containing events like the usage of the back, forward and reload buttons, as well as of bookmarks, hyperlinks, and the history. One part of the data sets was classified and served as training data to classify the remaining data sets. On the whole, only 53.8% of the data sets were classified correctly. The authors see the reason for these results in the strong impact individual differences have on the surfing behavior (Kellar and Watters, 2006). However, there may be further reasons: First, differences between Web sites concerning structure, layout and content certainly have an impact on the way users surf. Second, the authors considered only low-level events which probably do not describe the task-dependent behavior in an appropriate way.

3 THE STUDY

3.1 Set-up

20 university students and employees from different departments took part in the study. Their average age was 26.6 years.

The experiment was conducted with each participant separately, with an investigator leading through the procedure. The participants had to surf on one version of a German on-line newspaper, *Spiegel Online*.¹ Exercises were set, where each exercise represented either *Fact Finding*, *Information Gathering* or *Just Browsing* following the taxonomy of user tasks suggested in (Kellar et al., 2006). However, the category *Transaction* was not adapted as activities like these were not likely to occur in the study. It was decided to restrict the investigations to this Web site in

¹<http://www.spiegel.de>

order to eliminate the impact other Web sites of different structure and content might have on the users' behavior. Spiegel Online is structured like many other on-line newspapers with a start page containing the latest headlines and links to the different news categories like politics or economics. For each news category, extra index pages are offered, the articles each span one or more pages.

While the participants were working on the exercises, each of their actions within the browser was captured. At the end of the experiment a file containing all these actions in chronological order was created. Finally, the participants had to answer a few questions about their usage of the computer, the Internet and on-line newspapers as well as about their browser preferences.

3.2 Exercises

The participants had to go through four exercises which corresponded to the user tasks Fact Finding, Information Gathering and Just Browsing:

Exercise 1: The participants were asked to get familiar with the pages and to browse the Web site as they liked. The only restriction was to remain on Spiegel Online. This warm-up phase was meant to represent Just Browsing. No explicit time limit was given, but the investigator interrupted the activities after ten minutes if necessary.

Exercise 2: The participants had to look for a weather forecast of a certain town for the next day which corresponded to Fact Finding. The exercise ended as soon as the target was reached.

Exercise 3: Another Fact Finding exercise was set which was to find a certain football result.

Exercise 4: The test was concluded with an Information Gathering exercise. The participants were asked to collect information on the G8 summit. As the newspaper version used for the experiment was from June 8, 2007, the actual date of the summit, many articles about the topic were offered on the Web site at that time. To motivate the participants they were informed that they would have to answer a few questions about the topic afterwards. A time limit of ten minutes was given.

3.3 Data Collection

A Mozilla Firefox extension was used to capture events concerning mouse, scrolling, opening and closing pages and tabs, keyboard and the browser. Beside mouse clicks, every move of the mouse was recorded as well as the contact with page elements like hyperlinks, pictures or headlines. The scroll record also contained information on how much of the page was above and below the current view. Moreover, page events, the appearance and disappearance of pages, were captured. These events need not correspond to the appearance and disappearance into the user's sight. Sometimes, users like to load pages in tabs in the background, so that these pages are not seen until the tab is selected. That is why tab events are recorded as well. Furthermore, the usage of the keyboard is contained in the log. Browser events comprise the usage of browser buttons, like "back", "forward" or "reload", as well as the usage of all browser menus.

For each event additional information is saved, e.g. in the case of a mouse click a description of the element that was clicked is stored.

3.4 Data Analysis

First comparisons of the three user tasks *Fact Finding*, *Information Gathering* and *Just Browsing* will be presented concerning the following behavioral attributes:

- The duration of the exercise which corresponded to the user tasks
- The average duration of a page view
- The number of page views per minute
- The time spent on the newspaper's start page in proportion to the overall duration of the exercise
- The number of different news categories visited

A page view refers to the period of time a user is looking at a Web page. Pop-up windows and the use of different tabs are included in this concept; e.g. a pop-up window ends the page view of the page behind and starts a new page view for the pop-up window, whereas loading tabs in the background does not start a page view, but the selection of a tab does. The page views were derived from the log together with their duration and the URL.

The question is between which of the three tasks significant differences exist considering each of the five behavioral attributes. Analyses of variance with repeated measures are applied to find out if such significant differences are present. If this is the case, the outcome will be a p-value smaller than 0.05. To reveal

where the actual differences lie, t-tests with paired samples are used. Usually, the alpha level is also 0.05, but as there are more than two groups to be compared, the Bonferroni correction is applied, which is $1/3\alpha$ (0.0167) in this case, to avoid the alpha error cumulation. This correction is applied to all t-tests and leads to more conservative results. A significant difference is a hint which behavioral attribute to concentrate on for an automatic recognition of user tasks.

For the following evaluations, the respective values of exercise 2 and 3, both belonging to Fact Finding, were merged by taking the average values to obtain one single group for this task.

4 RESULTS

In this section, the results of the analysis of variance and the t-tests concerning the five above-mentioned behavioral attributes are presented. Moreover, descriptive data in the form of average values and standard deviations are given. Due to space constraints only some frequency distributions are presented.

4.1 Task Duration

Figure 1 illustrates the average values of the task duration, the time a participant worked on an exercise, with the concrete values at the bottom of each bar. The bars are furthermore enhanced with an error bar depicting the standard deviation. The error bar is weighted to the top and to the bottom by the proportion of the sum of the squared deviations from the average value. As can be seen in Figure 1, the overall duration of the exercises for Fact Finding is shorter than for the other two tasks. Information Gathering and Just Browsing seemed to require clearly more time. This impression is confirmed by the results of the analysis of variance with repeated measures with a significance indicated by $p < 0.001$ ($df = 2, F = 56,405$). T-tests with paired samples with an alpha level of $\alpha = 0.0167$ reveal significant differences between **Fact Finding and Information Gathering** ($p < 0.001, df = 19, T = -10.963$) and between **Just Browsing and Fact Finding** ($p < 0.001, df = 19, T = 9.681$). A significant difference between Just Browsing and Information Gathering is not given ($p = 0.315, df = 19, T = -1.033$).

These results match with the picture of the frequency distributions in Figure 2. The Figure also shows that the frequency distribution for Fact Finding already comes close to normal distribution whereas the other two tasks seem to be uniformly distributed.

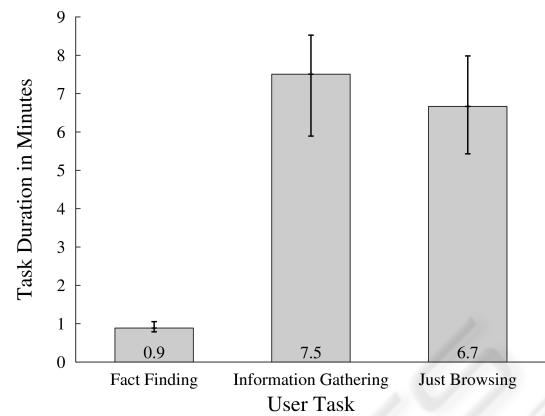


Figure 1: Overall duration of the exercises depending on the user task, $\sigma_{FF} = 0.27$, $\sigma_{IG} = 2.6$, $\sigma_{JB} = 2.5$.

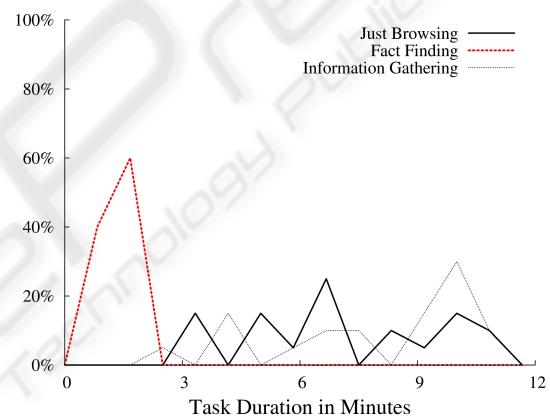


Figure 2: The frequency distributions for the attribute task duration.

Regarding the low number of values, however, this cannot be considered as certain.

4.2 Average Page View Duration

Looking at Figure 3, Information Gathering is on top concerning the average duration a user spends on a Web page. Just Browsing shows a smaller average page view duration, but the latter is still greater than the time Fact Finders spend on a single page on average. The analysis of variance indicates significant differences between the three user tasks ($p < 0.001, df = 2, F = 11,37$). According to the t-tests, these differences lie between **Fact Finding and Information Gathering** ($p = 0.001, df = 19, T = -3.729$) and between **Just Browsing and Fact Finding** ($p = 0.005, df = 19, T = 3.143$). With regard to the average page view duration, Just Browsing and Information Gathering do not seem to be significantly differ-

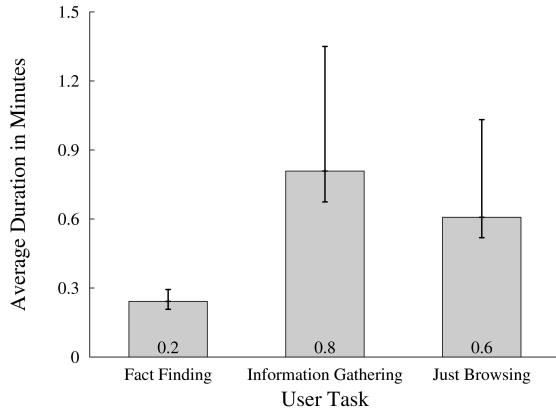


Figure 3: Average page view duration depending on the user task, $\sigma_{FF} = 0.1$, $\sigma_{IG} = 0.7$, $\sigma_{JB} = 0.5$.

ent ($p = 0.026$, $df = 19$, $T = -2.414$).

The high values of the standard deviations in the groups Just Browsing and Information Gathering are remarkable. A reason for this result may be that the participants were differently motivated when taking part in the experiment. Another reason could be general individual differences in the surfing behavior. If further tests, however, confirm strong differences between the individual users, this might turn out to be a problem for the identification of the user task by this attribute.

4.3 Number of Page Views Per Minute

Figure 4 indicates that Fact Finders seem to look at more pages during one minute than it is the case in the other two groups. This seems self-evident, because it is probable that users skim rather than read when looking for a fact. In contrast, the participants seemed to read more carefully when doing Just Browsing and Information Gathering. The analysis of variance results in a p-value $p < 0.001$ ($df = 2$, $F = 28.349$). The t-tests show significant differences between **Fact Finding and Information Gathering** ($p < 0.001$, $df = 19$, $T = 7$) and between **Just Browsing and Fact Finding** ($p < 0.001$, $df = 19$, $T = -5.293$). There is no significant difference between Just Browsing and Information Gathering ($p = 0.111$, $df = 19$, $T = 1.673$).

Figure 5 shows the frequency distributions for all three tasks. As can be seen, the curves indicate normal distributions.

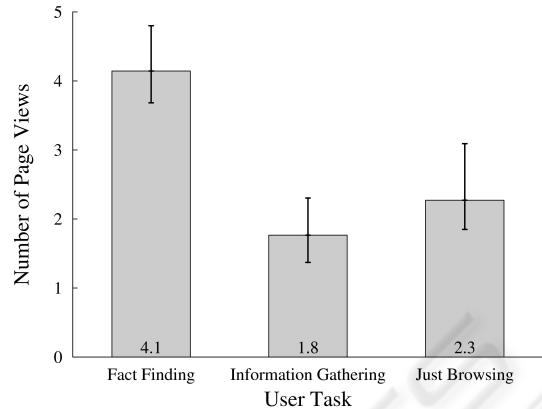


Figure 4: The number of page views per minute depending on the user task, $\sigma_{FF} = 1.1$, $\sigma_{IG} = 0.9$, $\sigma_{JB} = 1.2$.

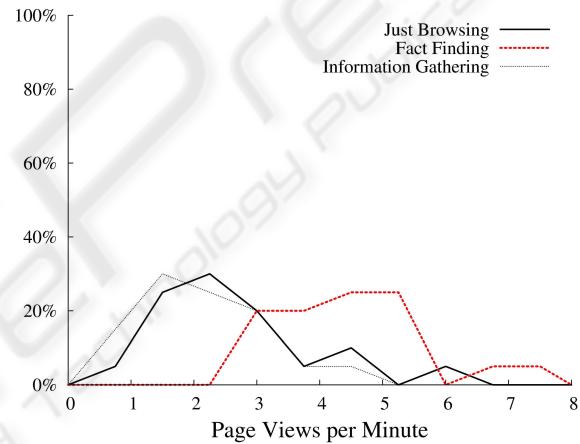


Figure 5: The frequency distributions for the attribute page views per minute.

4.4 Time Spent on the Start Page

The behavioral attributes considered so far are quite general and can be referred to other Web sites as well. The time spent on the start page compared to the overall duration, however, is an attribute very specific to on-line newspapers. As can be seen in Figure 6, a clear difference shows between Information Gathering and Just Browsing. It was common with Just Browsing as well as with Information Gathering that the participants had a few pages which contained a set of useful links and to which they frequently went back to try further interesting links. In the case of Just Browsing, the start page was such an important page, whereas pages more specialized to the given topic were used for Information Gathering. The outcome of the analysis of variance is a p-value of $p = 0.008$ ($df = 2$, $F = 5.446$), the concrete significant differences lie, according to the t-tests,

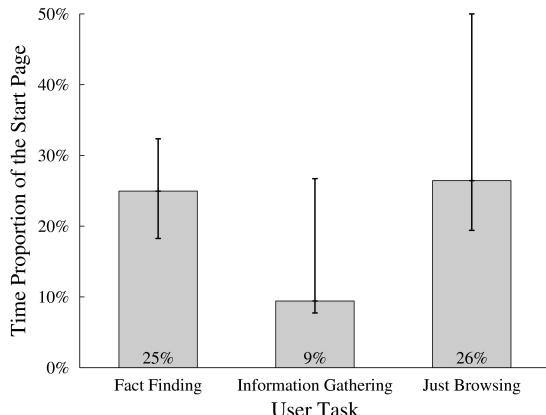


Figure 6: The time proportion of start page visits depending on the user task, $\sigma_{FF} = 14\%$, $\sigma_{IG} = 19\%$, $\sigma_{JB} = 24\%$.

between **Fact Finding and Information Gathering** ($p = 0.014$, $df = 19$, $T = 2.711$) and between **Just Browsing and Information Gathering** ($p = 0.007$, $df = 19$, $T = 3.051$). This time, there is no significant difference between Just Browsing and Fact Finding ($p = 0.802$, $df = 19$, $T = 0.255$). Again, the standard deviations are very high and have to be scrutinized in further tests.

4.5 Number of News Categories

Another behavioral attribute which is specific to online newspapers is the number of news categories the users are visiting to reach their goal. The news categories correspond to the categories presented in the navigation menu of the considered newspaper, such as politics, economics, sports etc. Figure 7 indicates differences between all three tasks which is confirmed by the analysis of variance ($p < 0.001$, $df = 2$, $F = 32.351$) and the t-tests revealing significant differences between **Fact Finding and Information Gathering** ($p < 0.001$, $df = 19$, $T = -6.020$), **Just Browsing and Fact Finding** ($p < 0.001$, $df = 19$, $T = 6.322$) as well as between **Just Browsing and Information Gathering** ($p < 0.001$, $df = 19$, $T = 4.714$). In contrast to Information Gathering and Fact Finding, Just Browsing meant that the participants were interested in several different news categories as they did not have a concrete target and surfed as they wished. Fact Finding was restricted to a specific service, the weather forecast, which does not belong to a news category, and one category, sports. That is why an average value of 0.5 occurs. The Information Gathering task could have led to different news categories like politics, economics and culture, the participants, however, mostly surfed on only one

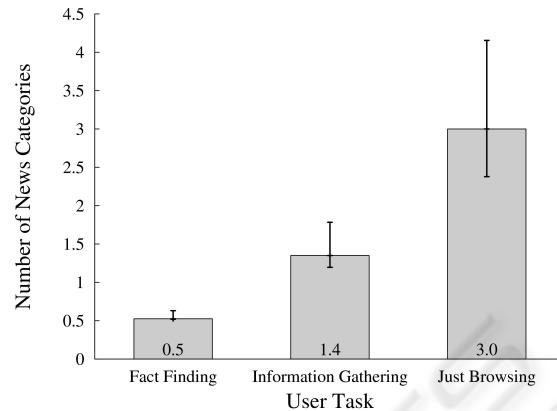


Figure 7: The number of news categories visited depending on the user task, $\sigma_{FF} = 0.1$, $\sigma_{IG} = 0.6$, $\sigma_{JB} = 1.8$.

or two categories.

Due to high standard deviations and a lack of a greater number of realistic Fact Finding and Information Gathering examples further tests should be made to confirm the results of the t-tests. However, the tendencies revealed here seem promising for the testing of hypotheses like "*Just Browsing involves more news categories than the other tasks.*"

4.6 Conclusions

The analyses of variance and the t-tests indicate that Fact Finding, Information Gathering as well as Just Browsing can be distinguished using the above-mentioned behavioral attributes. It depends on the observed attribute, however, between which tasks significant differences can be found.

Often, high standard deviations occurred. Their origin cannot yet be explained: either the participants were differently motivated in the experiment or their individual way of surfing is too different or there is a completely different reason. Further investigations with higher samples will hopefully bring more insight into this problem. Individual differences in the behavior might make the respective attribute impossible to use for the automatic identification of user tasks. On the other hand, it is interesting to know which behavioral aspects are more than others influenced by the individual.

With regard to three of five attributes, Fact Finding was always best to differentiate from the other two user tasks. The differences between Information Gathering and Just Browsing were not significant with these three attributes, although the difference concerning the average page view duration appears promising ($p = 0.026$).

The attribute describing the time spent on the start page in proportion to the overall duration indicated a difference between Information Gathering and Just Browsing which supplements the other three attributes. The number of news categories even showed significant differences between all three user tasks.

Until now, the identification of user tasks seems to depend on attributes which are connected to the type of Web site; e.g. the number of news categories visited. It will be interesting to find out if this is still the case when more aspects of the behavior will have been included.

Up to now, the potential of the collected data has not yet been exhausted as this is still a work in progress. Further analyses are necessary. They will be devoted to aspects like the scroll behavior; e.g. maybe slow scrolling to the bottom of the page indicates careful reading which might belong to Information Gathering. Another aspect is the touching of page elements, like pictures and titles. It is known that the position of the mouse cursor is often near the spot a user is looking at (Chen et al., 2001). Moreover the complexity of the page content, e.g. reflected in the amount of text, should be included in the analysis of page view durations. Page revisitations may also play an important role and should be considered as well. The list of analyses planned for the future is obviously long.

Based on the findings presented here and those further detailed analyses, hypotheses will be formulated which must be tested in a field study. This study will have to be conducted in a more natural setting; i.e. the recording tool has to be installed on the participants' computers and watch them in everyday activities with no exercises being set. The hypotheses will be like "*Fact Finding shows shorter page views than Just Browsing*", "*Fact Finding shows shorter page views than Information Gathering*" and "*Just Browsing and Information Gathering are equal in page view duration*." Confirming and refuting these hypotheses in a field study will draw a clearer picture of the task-dependent user behavior and bring us closer to automatic user task recognition.

To sum up, the findings indicate that the behavioral attributes presented here can be useful for an identification of the user tasks, yet, there is still more potential in the collected data for further analyses.

5 LIMITATIONS

The study was conducted with only 20 participants as it was only meant to be exploratory. The output of this study cannot be generally valid statements; it does,

however, reveal tendencies which will be translated into hypotheses that allow a more exact investigation on the relationship between user task and behavior.

The experiment was, moreover, conducted on one Web site of an on-line newspaper. This was done to reduce external influences on the behavior and to guarantee that the test setting is as similar as possible for each single participant. In a further study more Web sites will have to be included as well as a wider range in the age and the professional field of the participants.

Due to the age of the newspaper version a few pages, mostly videos, were no longer available. In this case, no page view was started as these situations only lasted for a few seconds and the participants had nothing to look at. Moreover, interactions with Flash could not be captured, this involved, however, only few multi-media pop-ups. Furthermore, changes of a page's content in the form of embedded JavaScript or video were not recorded as these changes did not really alter the page view itself.

Until now, security and privacy aspects have not been considered as the data was collected locally. For a remotely conducted study encrypted transfer of the event logs has to be implemented. Moreover, a functionality will be added to the event logging software with which the users can control when they allow the recording and on which Web sites. Concerning the future application, the best protection could be guaranteed when the task derivation is realized on the local computer and only the task name is sent to the Web site where the personalization takes place.

6 SUMMARY

A study was presented which investigated the relationship between the task and the behavior of Internet users. The study was exploratory as the main objective was to find out which attributes of the behavior are essential for a differentiation of user tasks. Multiple restrictions were set to guarantee that the participants faced the same conditions. The investigation focused on one version of an on-line newspaper to reduce the number of external influences in the form of content and structure of the Web site. Three user tasks were investigated, namely Fact Finding, Information Gathering and Just Browsing, which were represented as exercises the participants had to perform during the experiment. By setting the tasks, the switching between tasks and other distractions were prevented and an unambiguous impression of the connection between behavior and task could be gained.

In this paper five behavioral attributes were intro-

duced, among them the average page view duration and the number of news categories visited by the participants. For each attribute at least two pairs of user tasks showed a significant difference. Using these attributes, it is possible to differentiate between all three tasks.

The next step will be to examine further behavioral aspects, e.g. the scrolling. A question of particular importance will be whether the attributes necessary to recognize a user task are general or can be applied to only one kind of Web site. In the worst case this would mean that a task recognition strategy has to be developed for each type of Web site separately with specialized attributes added to the general attributes.

The findings of this study will be used for the formulation of hypotheses describing the relationship between user task and behavior. A further study in a more natural surrounding with more participants and thus more data will be conducted to prove these hypotheses. On the basis of the outcomes of this next study, methods of automatic user task recognition can be developed which will lead to a new quality of user support. Knowing the user's task means that the user's current needs are revealed. According to the task, different services could be offered. Fact Finders would certainly welcome a search functionality, whereas forums concerning the topic which the users are interested in can be offered when performing Information Gathering. In the case of Just Browsing, entertainment and distraction play an important role, thus, these users might be interested in pictures and videos. Moreover, the method with which link recommendations are found could be altered; in the case of Fact Finding, text mining is applicable whereas methods like the association rule mining can be used for the other two tasks. However, Information Gathering requires that the recommendations refer to the topic which is currently of interest. These are only a few of the manifold applications of user task recognition which makes clear how important further investigations on this topic are.

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