Development of a tool for the Design and Analysis of Experiments in the Web

Juan Miguel López Gil
Laboratory of Human-Computer Interaction for Special Needs
Computer Engineering Faculty of the University of the Basque Country in Donostia-San Sebastian
e-mail: acblogij@si.ehu.es
Thesis Director: Julio Abascal González

ABSTRACT
Considering the limitations of the current tools, our goal is to develop a tool that allows us the accomplishment of controlled experiments in the Web, fundamentally related with cognitive accessibility. This tool will have to be in charge to guide evaluators in the design of experiments, allow the collection of the information generated by the user during its interaction with the Web and facilitate and to give keys for its arrangement, analysis and later interpretation. Fitting us to the methodologic and technical requirements of the experimenters and taking advantage of the experience of previously made prototypes, the tool’s implementation will be made using the the XML standard and Java technologies.

Key words
Cognitive Accessibility, Web, Java, XML

1. INTRODUCTION
The accomplishment of this thesis is framed within the COGNIWEB project, whose goal is the study of the cognitive processes involved in the access to the Web in the case of users with auditory disability. The objective is to detect the keys that facilitate the understanding of the task, in order to be able to model the cognitive activity as much in navigation as in the access to the information contained in the Web pages. From this model, it is tried to offer design guidelines to Web page creators, to improve the cognitive accessibility of the Web sites. For the study of user cognitive processes during Web navigation, the use of the empirical method is required.

One of the main problems when the empirical method is applied in the study of user interaction with the Web, is the complexity that implies the collection of real-time data during the interaction, and the analysis of them. At the same time, these experiments have complex structural designs, that makes us think about the necessity to create them automatically in order to relax the burden on the experimenters. Therefore, the objective of the present thesis is to design and implement a computer tool that allows designing experiments, successfully obtains the information of the experimental subjects’ interaction with the Web and orders and analyzes the captured data, so that the experimenter can obtain the pertinent conclusions.

2. STATE OF THE ART OF CURRENT TOOLS FOR THE CAPTURE AND ANALYSIS OF WEB USER INTERACTION
There are many useful tools for the registry and analysis of observations made during the Computer-Human Interaction, or, in this concrete case, user interaction with the Web. The automatization on data capture makes possible the collection of excellent user and system information, like observable data, mouse actions, acquired knowledge, etc. This way, we are going to distinguish between the tools that attend in the capture of user conduct and the tools that attend in the capture of the knowledge acquired by the user.

The use of electronic annotations allows writing down the conduct of the user using events like hits, access, time, URL, path, page title, etc. In order to do this, we have two different types of tools, the Web server Logging Tools and the Client-Side Logging Tools.

The Server Logging Tools store the data generated by the HTTP communication between a server and a browser. There are many useful tools for the electronic registry, although they haven’t been developed with the purpose of evaluating accessibility. The main limitation of these tools consists on that they usually give an incomplete layout of user’s conduct mixing, for example, network latency with user’s answer time.

Client-Side Logging Tools capture data from the user interface and not only from the client-server communication. It allows the collection of more complete and exact data on the conduct of the user in the Web. In fact, these tools are usually used in contexts of controlled studies more than in commercial applications. Within this category of tools, we found the Listener, WET, WebVIP, ATNS and WebRemUsine.

Few tools allow automating the process of registry of user acquired knowledge in the scope of the Web interaction, and quite often investigators themselves are forced to develop tools ad hoc. The WebCat and the Rate module of the PCKnot program would constitute two exceptions. The WebCat tool automates the Card Sorting task, so the investigator can design the task,
introducing the concepts to be classified by users and gathering the result of this categorization. On the other hand, the PCKnot makes possible the design and mathematical analysis of the Relation Judgment task.

About the analysis of the captured data, most previously before mentioned tools are limited to present/display the information through graphs and are usually little flexible at the time to allow the experimenter selecting the concrete data it wants to analyze. In addition, they do not allow incorporating the new metrics generated in Literature, like disorientation degree (index L of Lostness [10]), St index of linearity and/or Cp index of complexity on the Web navigation route followed by the user [11]. Only WebRemUSINE [8] allows making comparisons with task models on which usability and accessibility problems can be inferred.

On the other hand, it does not exist any tool that at the same time automates the process of design, collect and analyze the navigation tasks we want to investigate (navigation, relation judgments, etc.). The process of the experimental situation design would be one of the most fundamental steps of this methodology.

When we carry out an experiment (or we use any other empirical method like the observation or the ethnography) we must decide which variables we are going to manipulate, control and observe, and on which way. Also, the data will have to be codified with a specific format, depending on the type of experimental design, so that they can be analyzed by the most used statistical packages (e.g. SPSS or Statistica). Some existing tools allow us to automate this process (MEL, E-Prime), but they can only be used with static tasks and not, like in our case, with dynamic tasks (e.g. navigation in the Web). Therefore, it should be another characteristic that our tool should have.

Finally, it is important to indicate that we cannot deal with isolated events (user Web logs) and user behaviours like synonymous. A single click has no sense on its own, we need models that frame these isolated events. It is necessary that the tool allows to integrate and recognize models of tasks (task search, tasks of understanding, judgments of relation, etc.).

Given to the deficits and deficiencies that we have found referring to utility and versatility of actually existing tools in order to attend the process of investigation in Web accessibility and usability, we think it is necessary to develop a tool that replaces these insufficiencies to carry out the investigation which we have mentioned in the introduction.

3. IMPLEMENTATION OF THE TOOL

The COGNIWEB project comes being developed since 2002 with the financing of diverse organizations (IMSERSO and Diputación Foral de Guipúzcoa). During the course of this temporary interval, user specifications have been modified and different prototypes of the tool developed.

Like a first step, a first prototype was developed, that performed the collection of data in the server. This prototype was developed to satisfy basic experimental requirements like user identification depending on its experimental condition (type of task, type of visited Web site, etc.) and the registry of visited pages, time spent in the pages, route followed by the users (since these data will be used to analyze the effectiveness and the disorientation of Web interaction task).

The technologies used in this prototype are Java technologies, object oriented programming language that allows the application to be re-usable and transportable and, mainly, admits changes with a reasonable time cost. We have used Servlets to collect the generated data, which has been kept in a MySQL database where it will be available for later analysis by the experimenters.

When evaluating the functionality of this prototype, it was stated that not only user Web actions were efficiently registered, but it also allowed the effectiveness analysis of a higher level behaviour like the task of searching targets in the Web. Nevertheless, in this prototype the autonomy of the experimenters was still limited referring to the process of the experimental situation’s design, reason why the final tool must make this design process automatically. It would also be desirable to correct the problem of the network latency, to assure the validity the user interaction data.

Due to these limitations, like following step, the design of a second prototype was needed in order to increase the automatization of the design of the experiments. These improvements would allow experimenters, without any programming knowledge, be able to design the experiments.

At the time of studying the appropriate technologies for the development of this second prototype, we have paid attention to the great possibilities of XML, a standard grammar system for the construction of customized marked languages. XML would offer us the opportunity to describe the design of psychologic experiments, so complex structurally, on a simple and effective way. This XML scheme could be used for both Client and Server Logging Tools to capture the interaction data according to experimenter’s specification.

In addition, we have also considered the use of a graphical environment for providing the user, in this case the experimenter, all the necessary options to create any type of experiment in a comprehensible way. This graphical environment has been developed using Java APIs and allows, using Java programming libraries, the creation of the experiments in XML.

When finishing the development of this second prototype, we have stated that the created structure satisfies the requirements of the experimenter, it describes all the parts of an experiment in a clear way and it has the option to extend or modify the experiment within the parameters established by the experimenters.

The prototypes developed during the project have supposed a great advance towards the attainment of the tool we want to develop, although they are still far away of being the final version, since they only include part of the global functionalities required by the tool we want to develop. The next point will describe the future work.
4. FUTURE WORK
The main future work lines will be:

1) How to translate experimenter’s requirement to XML format.

In this context, following with the way undertaken with the prototypes, we will continue using the Java technology (See Figure 1). This technology has demonstrated to be easily portable and has been able to correctly represent the structure of the experiments by means of XML and to provide the versatility necessary to be able to work with it without having to invest a great amount of time and resources.

![Figure 1](http://zing.ncsl.nist.gov/hfweb/proceedings/etgen-cantor/index.html)

Another one of the aspects to work is the description of different tasks from collection of data during the interaction of the user with the network, since the tool only codifies the task of free navigation by Internet, which is not enough, in most of the cases, to obtain conclusive data for the experimenters. Therefore, it is necessary for the tool to offer the opportunity to codify more tasks (search of targets, relation judgments), creating therefore a more useful tool.

Although the second prototype provided the investigators a sufficiently intuitive graphical interface in order to interact with the data in a simple way, it could be improved including alternative forms of graphical representation, like could be icons, frames that could visualize a scheme of the intermediate structure of the experiment, etc.

Another line to follow is the one of the automatic creation of experiments. Starting from the designed structure, we must transport the experiment to any computer to be able to make it and to gather the data for its later analysis.

2) How to implement the XML specifications within the experiment

As we have already mentioned in point 2, there are two different types of logging tools. We have chosen Server Logging Tools, but we have to overcome the limitations of this kind of tools, related mainly with the Web latency and the type of data recollected.

To overcome the Web latency, we need to design an architecture that allows us to gather those data of the user and send them to the experimenter so that this one can analyze them.

In the proposed architecture (See Figure 1), the user would access to the Web by his browser; this one would be connected to a Proxy (with a cache within to decrease Web latency storing already visited pages) that, by means of a module Javascript, would be in charge to adapt the Web pages by which the user navigates in order to be able to receive the information of the interaction of the user with the Web, and, as well, to send orders or instructions to this one (e.g. Search for a X target in a certain page Web), actions that could change dynamically according to the answer of the users. The Proxy would be connected to a Web server, where they would be lodged the Servlets that will implement the required functionalities, like the ones concerning the XML experiments or sending the data of the Web user interaction for his analysis.

3) Management of received data

The data would the storaged in a data base, like in prototype 1. The user Web interaction data would be presented/displayed in a flexible way to the experimenter, who could make queries to visualize and to analyze the interaction data. We will be able to analyze the data according to standard metrics like index L of Lostness [10], St index of linearity and/or Cp index of complexity on the Web navigation route followed by the user.

5. CONCLUSIONS

The Cogniweb project reveals the necessity to carry out empirical investigation in the field of the interaction of the users with the Web, to be able to arrive to conclusive theories that would allow us, for example, to extract guides to design accessible Web sites. With this goal in mind, we must finish implementing the proposed tool, so that this way the experimenters have the necessary resources to carry it out.

The Java technology will allow us to implement the tool so that it fulfills the specifications and requirements expressed by the experimenters, a easily portable and multipurpose tool that eliminates the network latency when taking response time data from the users, and whom the structure of the experiments represents correctly and facilitates the arrangement and analysis of data. Definitely, a tool that provides the versatility necessary to be able to work with it without having to invest to great amount of time and resources.

6. REFERENCES


The design of experiments (DOE, DOX, or experimental design) is the design of any task that aims to describe and explain the variation of information under conditions that are hypothesized to reflect the variation. The term is generally associated with experiments in which the design introduces conditions that directly affect the variation, but may also refer to the design of quasi-experiments, in which natural conditions that influence the variation are selected for observation. Analyses of Web experimental methodology (e.g., Reips, 1995c, 1997b) were supported by the survey. Consequently, most survey respondents stated that they would certainly conduct. The web experiment 5. â€¢ Very limited sample populations, which raises the question whether psychological theories and body of research are too narrow in scope (for decades subjects have been mostly young students of local nationality [Reips & Bächtinger, 1999; Schultz, 1972; Smart, 1966]; therefore many results may be specific for young. Holding N constant. This applies to Web experiments also, and the Web offers a nice feature for aiming at specific person types. One can direct Web participants to different Web studies. Design of Experiment is a powerful data collection and analysis tool that can be used in a variety of experimental situations. It allows manipulating multiple input factors and determining their effect on a desired output (response). By changing multiple inputs at the same time, DOE helps to identify important interactions that may be missed when experimenting with only one factor at a time. We can investigate all possible combinations (full factorial) or only a portion of the possible combinations (fractional factorial). I have referred some other website but no website provided this much detailed information about project management really thanks for the website for guiding the professionals to be good at our project management carriers. Clive. Clear and understandable notes. After studying experimental design a researcher or statistician should be able to: (1) choose an experimental design that is appropriate for the research problem at hand; (2) construct the design (including performing proper randomization and determining the required number of replicates); (3) execute the plan to collect the data (or advise a colleague on how to do it); (4) determine the model appropriate for the data; (5) fit the model to the data; and (6) interpret the data and present the results in a meaningful way to answer the research question. In a book on the design and analysis of experiments, there is no longer a need to show all the computational formulas that were necessary before the advent of modern computing. This task view collects information on R packages for experimental design and analysis of data from experiments. With a strong increase in the number of relevant packages, packages that focus on analysis only and do not make relevant contributions for design creation are no longer added to this task view. Please feel free to suggest enhancements, and please send information on new packages or major package updates if you think they belong here. Contact details are given on my Web page. Experimental design is applied in many areas, and methods have been tailored to the needs of various fields. This task view starts out with a section on the historically earliest application area, agricultural experimentation.