2011 International Conference on Social Science and Humanity
IPEDR vol.5 (2011) © (2011) IACSIT Press, Singapore

Human Behavior on Web: What is Known

Peter Géczy, Noriaki Izumi, Shotaro Akaho, Kôiti Hasida
National Institute of Advanced Industrial Science and Technology (AIST)
Tokyo and Tsukuba
Japan

***Abstract*—Elucidation of human behavior in digital and virtual environments is quickly gaining eminent position in web research. The driving forces are wide-ranging. They originate from both academic and commercial domains. The academic inquiry into human web behavior is fundamentally oriented toward exploring, analyzing, understanding, modeling, and applying the findings. The commercial sector is exploring human-web interaction characteristics for user exploitation. It focuses primarily at novel and improved revenue generating possibilities from behavioral targeting, profiling, and related synergies. Although academic and commercial sectors have generally different targets, they both contribute to deeper understanding of human web behavior. The human web behavior mining is a relatively young domain; however, accumulated knowledge has been highly beneficial. Modern trends in web design and development already incorporate the elements of human-web interaction characteristics. The presented work highlights the status quo in human web behavior research. It summarizes the essential known features of human web behavior and their practical implications.**

Keywords: human web behavior; world wide web; web mining; clickstreams; interactions; exploratory analysis.

I. INTRODUCTION

World wide web has been evolving from its early static form to a dynamic interactive environment [1]. Dynamically generated content, vector graphics, rich internet applications, multimedia, and other technologies have become common in web sphere. These new dynamic and interactive technologies enhance user experiences and enable rich interactions across various modalities.

Relative novelty of the web as a major interactive medium presents numerous research opportunities, but also challenges [2]. It inevitably highlights an increasing commercial potential. Emergent web research, development, and implementation substantially benefit from observation, analysis, and deeper understanding of human web behavior [3]. The essential elements of human web behavior have already found their practical place in design and deployment strategies.

Despite the ongoing innovation and progress in web development, our interaction modalities are tightly linked to input/output hardware devices. The most commonly used devices encompass three essential modalities: visual□display; auditory□audio input and output (e.g. microphone and speakers); and tactile□touch screen, keyboard, and mouse. Future devices may expand and more suitably synthesize the interaction modalities, and possibly enrich our experiences in future digital environments.

On the surface, a human web behavior appears to be relatively simple. A user accesses a web document via a browser. A browser renders the document containing audiovisual information and links to other documents and resources. After consuming the audiovisual information on a web page, a user decides on a follow-up resource—usually indicated by a hyperlink. Clicking on the hyperlink, the following resource is rendered in a browser. It may again contain audiovisual information and hyperlinks to other documents. This process is repeated. Thus, the essential interaction and behavioral pattern emerges: information consumption → click → information consumption → click → information consumption, and so forth. This is called a click stream (or click train, etc.) [4]. It appears plain; however, the seemingly simple click stream contains vast amount of information about human browsing patterns and habits.

Click stream analysis and tracking analysis provide vital knowledge of how we behave and interact in digital environments (see Figure1). Click stream analysis mostly addresses the interactions and behaviors that extend beyond a single document or even a web site. It has capability to explore interactions where humans access sequences of web documents. Tracking analysis refers to analyzing movement of eye, mouse, or touch (e.g. eye-tracking or mouse-tracking). Tracking is generally preferable for addressing human behavior at a single web document; i.e. tackling usability and design characteristics of a single web document.

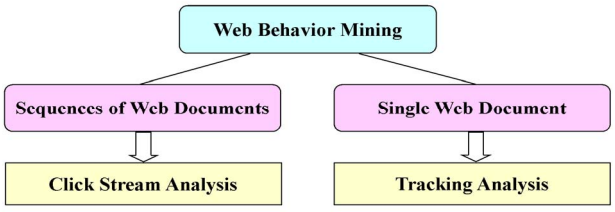

Figure 1. Differentiation of web behavior mining approaches.

There are also other methods, such as survey and protocol analysis [5, 6], for observing human web behavior. However, the focus of this article is on click stream analysis and tracking analysis methods. We present contemporary knowledge of human web behavior and highlight selected practical implications.

II. CLICK STREAM ANALYSIS

It has been initially assumed that human web interactions are generally random in nature. Relatively recently it has been observed that our interactions are strongly

inhomogeneous and far from random. The temporal dynamics of human interactions in web environments exhibit shorter periods of activity followed by longer periods of inactivity [7]. Individuals execute certain tasks rapidly, whereas other tasks are completed after a substantial delay. The timing of the task execution is being considered to be perceptually prioritized [8]. Perceptual prioritization relates to our cognitive processing of information contained in web documents.

Observed nature of our temporal dynamics provides a justification for temporal segmentation of human web interactions. It is relevant to partition human web interactions into sequences representing various complexities of behavior depending on the detected delays [3]. This leads to dividing human web behavior into two essential elements: sessions and subsequences. Extensive click stream sequences are initially divided into sessions, and sessions are further divided into subsequences. The principle is illustrated in **错误！未找到引用源。**. The division is done with respect to the user activity and inactivity. Activity and inactivity periods should satisfy certain criteria.

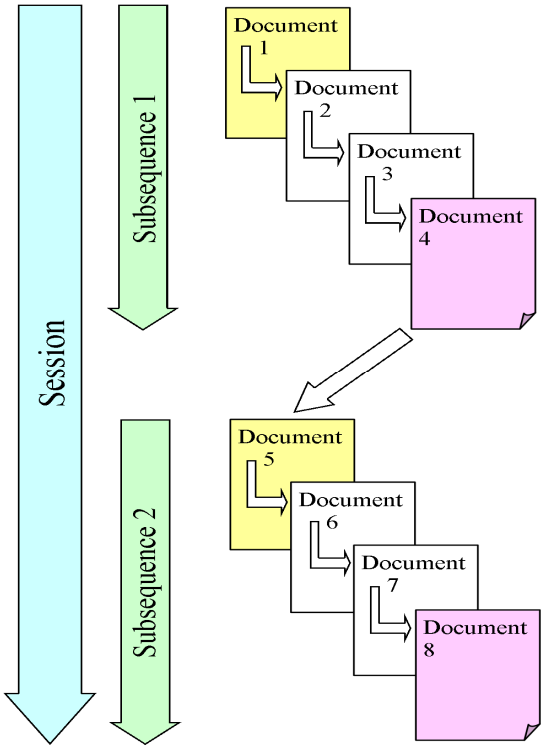

Figure 2. Click stream segmentation. Larger segments are sessions. Smaller segments are subsequences. Illustrated session contains two subsequences.

Consider for instance the following knowledge worker activity. At the beginning of a working day, a user accesses an internal web-based attendance service to record the starting time of a working day (subsequence 1). Then, the user proceeds to an internal web bulletin board (with organizational announcements) and reads the latest update regarding external collaboration policy (subsequence 2). The knowledge worker's browsing session consists of two subsequences representing distinct tasks: attendance recording and reading organizational announcement.

A. Pertinent Findings

Click stream analysis contributed several important findings about human web behavior. The findings relate to browsing strategy, segmentation of tasks, interaction dynamics and numerous other aspects. We concisely present selected significant human web behavioral characteristics and their implications.

- **Browsing Strategy**. General browsing strategy reflects knowledge of the starting navigation point and familiarity of the traversal pathway to the target. Users, if they know where they want go, remember where to start and how to get throughout the intermediary documents to the desired target. The main attention is paid to the starting and ending documents. They should be designed well.
- **Task Segmentation**. More complex interactive and browsing tasks are divided into several simpler subtasks. On average, complex tasks are composed of three simpler subtasks. In other words, average sessions contain three subsequences. This is a useful practical rule when implementing web-based business processes. For instance, in customer payment processing, it is beneficial to design and implement the process within three stages.
- **Active Dynamics**. Active interactions in web environment are in the range of seconds. This applies also to the rapid transitions between documents. Thus, the interactive elements in web documents (e.g. multimedia) should be designed in a way that allows users to interact with them relatively fast. For example, controls or dynamic segments in online games should be designed for seconds-level interactions.
- **Passive Dynamics**. On the other hand, passive interactions are in the range of minutes. Users' attention span at the target is approximately seven minutes. This has various implications for passive information presentation, such as text. If information is presented in a textual form, seven minutes translates to approximately seven-hundred words (considering the average adult screen reading speed of 120 words per minute and 80% comprehension).
- **Habituation**. Behavior and interactions of users significantly habituate as they familiarize with the environment. Their interactions become faster, their attention span becomes shorter, and their behavior becomes less exploratory. This presents implications for alternations of web environment and interfaces. For instance, substantial modifications of interfaces in web-based platforms result in prolonged learning curves that lead to decreased effectiveness of knowledge workers. Consequently, lower working effectiveness may lead to potential financial losses for organizations.

III. TRACKING ANALYSIS

Tracking and analyzing eye movement and/or mouse movement are useful methods for exploring usability and design of individual web documents. It is argued that the tracking methods, in principle, analyze users' attention [9]. Eye tracking methods utilize devices for monitoring eye movement when user watches a web document. Data on where user was looking, for how long, and how he/she visually scanned a web document are obtained. Various visualization and analysis techniques, such as heatmaps, are used for extracting knowledge [10, 11]. Analogously, mouse tracking deals with cursor positioning data. Collected data contains usually information on where user positioned cursor on a document, for how long, movement of cursor on a document, speed/acceleration of movements, etc. [12]

Eye tracking is generally significantly more costly than mouse tracking, since it requires special hardware and setup. Eye tracking can also be performed generally on a smaller number of subjects than mouse tracking. Thus it is important to choose the experimental subjects appropriately. However, eye tracking is considerably more accurate at detecting attention focus (some reports suggest almost 100% accuracy for eye tracking, while mouse tracking accuracy is around 80%).

A. Pertinent Findings

- **Initial Visual Scan**. When we first see a document, we perform a rapid visual scan from the upper-left corner horizontally right and then vertically down. This scanning pattern is significant for people who read left-to-right and top-to-down (e.g. in western languages). Right-to-left and top-to-down reading people (e.g. in Japanese, Arabic) scan according to their reading habit. Hence, linguistic and cultural dimensions are important.
- **Scanning Pattern**. Depending on habitual reading pattern, we analogously scan the entire document. That is, for left-to-right and top-to-down case, the scanning pattern is similar to 'E' (with several horizontal scans). Analogously, for right-to-left and top-to-down readers, the scanning pattern has a form similar to '□'. Applied to web design, this implies that the most important information should be placed in the upper left or right corners—depending on document localization and audience.
- **Eye and Mouse Movement Correlations**. There is a strong correlation between eye and mouse movement. Users move mouse cursor according to their focus of attention. Thus, mouse related events in web design should account for and accommodate visual attention.

IV. CONCLUSIONS

We presented the status quo in human web behavior and interaction research. Selected pertinent findings provide actionable knowledge for web researchers and practitioners. Knowledge of human web behavior is derived from click stream analysis and tracking analysis methods. Both approaches provide viable observations of human behavior in web environments. While tracking approaches address usability and attention aspects related to a single document, click stream approaches extend to sequences of accessed documents. Click stream methods allow for observations of browsing strategies, segmentation of tasks, passive and active interaction dynamics, and habituation characteristics. Tracking techniques elucidate where users focus their attention, as well as visual and motoric document scanning patterns. Synthesis of observations from both approaches presents a comprehensive perspective on human web behavior.

ACKNOWLEDGMENTS

The authors would like to thank the members of the Social Intelligence Technologies Research Laboratory, Mathematical Neuroinformatics Group, and Center for Service Research at the National Institute for Advanced Industrial Science and Technology (AIST) for their valuable comments and discussions.

REFERENCES

[1] T. Berners-Lee and R. Cailliau. World wide web: Proposal for a hypertext project. http://www.w3.org/Proposal.html, November 1990.

[2] J. Grudin. Three faces of human-computer interaction. Annals of the History of Computing, vol. 27, pp. 46–62, 2005.

[3] P. Géczy, S. Akaho, N. Izumi, and K. Hasida. Mining human web behavior mining. International Journal on WWW/Internet, vol. 6, no. 2, pp. 1-15, 2008.

[4] R. E. Bucklin and C. Sismeiro. A model of web site browsing behavior estimated on clickstream data. Journal of Marketing Research, vol. 40, pp. 249–267, 2003.

[5] P. van Schaik and J. Ling. Using on-line surveys to measure three key constructs of the quality of human-computer interaction in web sites: psychometric properties and implications. International Journal of Human-Computer Studies, vol. 59, no. 5, pp. 545–567, 2003.

[6] R. Benbunan-Fich. Using protocol analysis to evaluate the usability of a commercial web site. Information and Management, vol. 39, pp.151–163, 2001.

[7] A.-L. Barabasi. The origin of bursts and heavy tails in human dynamics. Nature, vol. 435, pp. 207–211, 2005.

[8] Z. Dezso, E. Almaas, A. Lukacs, B. Racz, I. Szakadat, and A.-L. Barabasi. Dynamics of information access on the web. Physical Review, E73:066132(6), 2006.

[9] R. J. K. Jacob and K. S. Karn. Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. In J. Hyona, R. Radach, and H. Deubel, Eds., The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research, pp. 573–605, Elsevier Science, Amsterdam, 2003.

[10] A. T. Duchowski. Eye tracking methodology: theory and practice. London: Springer-Verlag, 2003.

[11] J. Nielsen, and K. Pernice. Eyetracking web usability. Pearson Education: New Riders Press, 2009.

[12] E. Arroyo, T. Selker, W. Wei. Usability tool for analysis of web designs using mouse tracks. In Proc. of Human Factors in Computing Systems, pp. 484 – 489, Montréal, Québec, Canada, 2006.