Engineering Applications of Artificial Intelligence 26 (2013) 1469–1478

Contents lists available at SciVerse ScienceDirect

Engineering Applications of Artificial Intelligence

journal homepage: www.elsevier.com/locate/engappai

Combining eye-tracking technologies with web usage mining for identifying Website Keyobjects

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ARTICLE INFO

Article history:
Received 3 August 2012
Received in revised form
4 January 2013
Accepted 14 January 2013
Available online 4 February 2013

Keywords:
Web mining
Eye tracking
Website Keyobjects

ABSTRACT

This paper introduces a novel approach for collecting and processing data originated by web user ocular movements on a web page, which are captured by using an eye-tracking tool. These data allow knowing the exact web user's eye position on a computer screen, and by combining them with the sequence of web page visits registered in the web log, significant insights about his/her behavior within a website can be extracted.

With this approach, we can improve the effectiveness of the current methodology for identifying the most important web objects from the web user's point of view, also called Website Keyobjects. It takes as input the website's logs, the pages that compose it and the interest of users in the web objects of each page, which is quantified by means of a survey. Subsequently, the data are transformed and preprocessed before finally applying web mining algorithms that allow the extraction of the Website Keyobjects.

With the utilization of the eye-tracking technology, we can eliminate the survey by using a more precise and objective tool to achieve an improvement in the classification of the Website Keyobjects. It was concluded that eye-tracking technology is useful and accurate when it comes to knowing what a user looks at and therefore, what attracts their attention the most. Finally, it was established that there is an improvement between 15% and 20% when using the information generated by the eye tracker.

1. Introduction

In recent years, there has been a new research area called Web Mining, which studies different ways of extracting information from data generated on the Web. With this knowledge, it is possible to develop techniques and algorithms to attract and retain users on a website. Specifically, this area applies data mining techniques to data originated on the Web with the aim of obtaining valuable information to continuously improve a website in terms of design and content, among other aspects.

An interesting result that has been achieved in this field are the Website Keywords (Velásquez et al., 2005), defined as a word or set of words used by users in their information search process, and which characterizes the content of a website or page. After finding them, the sites can be redesigned according to the needs and requirements of its users and, thus, be in the vanguard. Although identifying the Website Keywords of a site helps to know the preferences of users, the methodology that discovers them only focuses on the textual content, leaving out the analysis of the multimedia content of websites. For this reason, in Dujovne and Velásquez (2009) the methodology was extended and integrated with both the textual content and the multimedia content in their analysis.

In Dujovne and Velásquez (2009) web objects are defined as "any structured group of words or a multimedia resource that is present on a web page that has metadata which describe its content". Also, they characterized a Website Keyobject as a web object that captures the attention of the users and that characterizes the contents of a website (Velásquez et al., 2011). From the above definitions it is possible to deduce that every website consists of a set of web objects and that the set of Website Keyobjects it has is a subset of the former.

Also in Velásquez et al. (2011) the designed methodology allowed the identification of the Website Keyobjects of a site. These, like the Website Keywords Velásquez (2011), give guidelines for the websites to be redesigned according to user requirements. This methodology requires knowledge of the time spent by users on the web objects, i.e., how long a user spends looking at each web object. To determine the permanence time they propose two steps, sessionization and the application of a survey.

A. *Sessionization*: It is the process that reconstructs user sessions. A session is the sequence of web pages visited by a user while browsing a site. The necessary data for a session

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0952-1976/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.engappai.2013.01.003

reconstruction is registered in the web log files. Through this process it is possible to determine, for example, the permanence time of a user on each page, among other things.

B. *Application of a survey*: It refers to the implementation of a survey on a control group, wherein web objects were sorted according to their importance within each page of the website.

By mixing the two processes, the time spent by users on the web object is estimated. However, thanks to the eye-tracking technology it is possible to dispense with this survey. Eye-tracking technology allows knowing what a person looks at as a function of time (Ali-Hasan et al., 2008). By applying this technology to users browsing a site it is possible to measure the time spent on each web object. In this sense, if it was possible to quantify the permanence time of a control group of users on web objects, an improvement to the methodology developed in Velásquez et al. (2011) could be made, i.e., determining the Website Keyobjects more accurately.

Section 2 describes the related work with the paper proposal, explaining concepts like web mining, the nature of the data originated on the Web and how eye-tracking techniques have facilitated the application of its usability for analyzing computer-based systems. Section 3 describes the elemental issues for understanding how the eye-tracking techniques work. Section 4 shows a methodology for identifying Website Keyobjects, the main problem to be tackled in this paper. In Section 5, the whole set of experiments performed for demonstrating the practical utility of eye-tracking tools in the scope of web mining is shown. Finally, Section 6 presents the paper's conclusions and future work.

2. Related work

In this section a conceptual framework about the traditional web mining process, which uses data originated on the Web, and the possibility of using other kinds of data, for instance those generated by the application of eye-tracking tools, will be introduced.

2.1. Data originated on the web

The data that are originated on the Web are classified into three types (Velásquez and Jain, 2010): content, structure and usage.

1. *Content*: It refers to the objects on Web pages, including text, images, sounds and videos, in other words, all that can be seen on a page. Thus, the text can be presented in a semi-structured, highly structured or unstructured way. On the other hand, the multimedia content requires metadata that describe it; however, it is uncommon to find these descriptions.
2. *Structure*: They are the links between pages. Usually when there is a link between two pages, these are related by their content. If a set of pages are linked together, a common information community is created.
3. *Usage*: It is the data generated by users in their navigation process, as Web servers store each request made by users in a file called a web log.

2.2. Web mining

Web mining is the application of data mining to data originated on the Web (Chang et al., 2001; Velásquez and Jain, 2010). It is conceived as a product of the intersection of several research areas such as databases, information retrieval, artificial intelligence, especially the sub-areas of machine learning and language processing (Etzioni, 1996). Research in this field is experiencing significant growth because of the large amount of data available for analysis (Kosala and Blockeel, 2000). This is no small task, considering that the Web is a large collection of heterogeneous, declassified, distributed, time-varying, semi-structured high-dimensional data (Pal et al., 2002).

Since the data originating from the Web can be classified into three categories, it is natural that Web mining also branches into these categories. Their nature differs in the way that they are set up as different problems. The sub-areas are (Velásquez and Palade, 2008; Kosala and Blockeel, 2000; Velásquez and Jain, 2010):

1. *Web content mining* (WCM): It is targeted to discover useful information from Web documents. WCM is not only limited to analyzing the text of Web pages, but also includes other types of documents such as images and videos. However, the analysis of this data type, called multimedia data mining, does not receive as much attention as text analysis.
2. *Web structure mining* (WSM): It is the sub-area which studies the links on Web pages. The pages and links are modeled as the nodes and arcs of a directed graph, respectively. The arc starts on the node that represents the page that has the link and ends at the node representing the page being targeted.
3. *Web usage mining* (WUM): It is focused on the application of data mining techniques to discover useful patterns that can predict user behavior while interacting on the Web. To discover these patterns, the browsing sessions, understood as the sequence of pages that a user visits while surfing the web, are analyzed.

2.3. Web user perception

One important question when a web page is designed is about what the web user will perceive and understand concerning the content and structure shown (Lee et al., 2004). Perception is a function of thinking, i.e., how we recognize and interpret an object by using our senses for encoding, storing and integrating information related to some previous knowledge.

Understanding web user perception is important for creating a better website design, which will finally attract and retain the users. However, it is not a simple task, because this perception is related to the web user's knowledge background, i.e., his/her personal experience (Novak et al., 2000).

According to the conceptual model of flow proposed by Hoffman and Novak (1997) during the web user's navigation, the website structure is perceived as a cognitive experienced state, which is determined by "*high levels of skill and control*; *high levels of challenge and arousal*; *focused attention*; *and is enhanced by interactivity and telepresence*". Perhaps the unique factor that can be influenced directly by construction of the website is the web user's focused attention. However, it could be a double-edged sword, i.e, attention can be captured because the website content is attractive or because the content is unpleasant, in which case the web user will never again visit the site.

In any case, to understand what the web user is looking for, or at least to know what elements in the website capture his/her attention it is useful to improve the site structure and content. In that regard, many approaches have been addressed, usually from the information and knowledge extracted from web data (Kosala and Blockeel, 2000; Pal et al., 2002) and also from the usability theory for creating web-based systems (Nielsen and Pernice, 2009).