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Boulevard: Affective Adaptive User Interface

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Abstract. Applications had grown into complex applications, where such complexity negatively impacts usability by owing to provide single static user interface that should meet all users. We focus on adaptive user interfaces, which automatically customize user interface without direct user's invitation. In our previous work we have developed a novel adaptive interface called Boulevard, a panel container with a user interface automatically personalized to an individual user. We present our work-in-progress focused on enhancing Boulevard by utilization of affective computing and eye tracking, since considering user's current emotional state and point of gaze may play important role for performance of adaptive user interface.

Keywords. adaptive user interface, affective user interface, multimodal interaction

Introduction and Related Work

The today's desktop applications are usually very complex and offer much functionality. Unfortunately, the excess of provided functionality was identified as a substantial source of dissatisfaction by many users [1]. Such disproportion between provided and actually used functionality makes personalization of the user interfaces beneficial for users.

Ceaparu et al. conducted a study on determining the causes of users' frustration [2]. They presented very discouraging results when they showed that users experience frustration on a frequent basis. The applications in which the frustrating experiences happened most frequently were identified as web browsing, e-mail, and word processing. One of the frequently reported causes of frustration was hard-to-find features.

Our interest focuses on word-processing applications, as they are used by many users and various types of users, from beginners to professionals. More importantly, today's word processors are complex applications and the above-mentioned disproportion between provided and actually used functionality affects them as well, which was reported in an interesting study focused on Microsoft Office users, conducted by McGrenere and Moore, with a poignant title *Are We All in the Same Bloat?* [1].

We also focus on Enterprise Resource Planning (ERP) systems, since today ERP systems are often large-scale complex systems covering a huge number of different tasks performed across an entire organization. It is widely acknowledged that ERP systems suffer from complex user interfaces, which negatively affects the usability [3]. It has also been reported that small improvements in usability of ERP system can bring large benefits [2].

Adaptive user interfaces (AUIs) are systems that adapt their user interface to a particular user. Most AUI research has been focused on menu adaptation, where such adaptation mechanisms are based on reordering or removing menu items. Mitchell and Shneiderman [4] developed a system that reorders menu items using their relative frequencies of usage. Naturally, there were attempts at the adaptation of a toolbar, e.g. performed by Gajos et al. [5]. AUIs have been criticized for violating various usability principles, like controllability, predictability, transparency and unobtrusiveness. Bakov et al. proposed an approach to controlling adaptive behavior in recommender systems, which allows users to get an overview of personalization effects, view and edit the user profile that is used for personalization [6]. The results of the user study showed that such an approach helps to solve the transparency and controllability issues. Another study conducted by Gajos et al. evaluated how predictability and accuracy of AUI affect performance of UI [7], the results show that increasing predictability and accuracy led to strongly improved satisfaction.

Human factor engineering is the application of knowledge about human capabilities. Human factors researchers usually use eye tracking and EEG (Electroencephalography). From such inputs it is possible to deduce the subject's behavior and psychological state using emotion recognition algorithms. The above-mentioned devices are usually used for studies and evaluations. However, such devices are becoming widely-used as an input device. Nowadays, there are systems that integrate such modalities, originally developed for people with disabilities, in order to increase usability of such a system by common users. A very interesting study on human factors in the design of adaptive user interface was conducted by Elena Zudilova-Seinstra [8], where she suggested the criteria for the user model guiding and controlling the adaptation process.

Electroencephalography (EEG) provides the one-way non-invasive interface between brain and computer: Brain-Compuer Interface (BCI). The stream of data recorded from the user's brain must be processed by an algorithm designed to decode the user's intentions or emotional state. Utilization of EEG as a computer controller has been proposed by various authors, e.g. by Solovey [9].

Usage of EEG to detect human satisfaction was performed e.g. by Esfahani et al. [10]. Their experimental results show an accuracy of 79.2% in detecting the human satisfaction level using EEG headset which records brain activity from 14 locations on the scalp. Another study [11] evaluated the detection accuracy of one of the first BCI intended for personal use: the Emotiv EPOC. Provided results indicate that the Emotiv EPOC performs its function as a BCI with an acceptable level of accuracy. The headset was evaluated also by Wright in his dissertation [12], where he evaluated accuracy of measured levels of excitement, engagement and frustration in order to establish the validity of the Emotiv EPOC Affectiv suite. He found that self-reported levels of engagement and excitement correlated with levels measured by the headset. Frustration, however, did not. Wright implemented Attentive User Interface, which distinguish between attentional states of the user (rest, moving, thinking and busy) and regulate notifications in a instant messaging. Similar approach was also used by Chen et al. [13], where they identified appropriate notification in 83% of cases. Real-time EEG based applications were developed and evaluated also by Souriana et al. [14]. They developed an emotional avatar, music therapy, EEG music player, which plays music in according to the user's emotional state, and interactive storytelling application.

An interesting study which combines both approaches (EEG and eye tracking) was performed by Putze et al. [15]. They used Eye tracking and EEG as additional input modalities for event selection in video stream. From eye tracking, they derived the spatial location of a perceived event and from patterns in the EEG signal they derived its temporal location within the video stream. They achieved a temporal accuracy of 91% and a spatial accuracy of 86%.

One of the typical property of the most AUI is that they adapt user interface at the moment when a new pattern or preferred functionality has been recognized, without considering the user's emotional state or current situation on wider context. When user interface will take into account user's cognitive states, such as interest, workload, frustration or fatigue, it is possible to adapt the user interface to the user's psychological state, which may have impact on the performance of AUI (from reception by user point of view). In a recent paper from Tan et al. [16] they claim that AUIs can benefit from having knowledge on the user's emotion. Similar claims can be found in various papers (e.g. in [17]).

1. Adaptive User Interface Boulevard

In our previous work we have focused on traditional adaptive user interfaces where advanced inputs such as EEG or eye tracker was not concerned. However, we have already designed, developed and evaluated a prototype of an adaptive user interface, which is integrated into real complex applications, namely: OpenOffice.org [18] and OpenERP [19]. Implementation to SAP ERP is under development.

Our system named Boulevard (depicted on Figure 1) is represented as an additional panel container window containing the personalized user interface of the application. Since the panel container centralizes the most preferred functionality of the application, the user's effort required to find a command in complex menus or toolbars is reduced. In contrast to most of adaptive user interfaces these days, Boulevard does not modify the original part of the interface destructively (e.g. menu or toolbar contents or structure) so that a user is able to clearly understand which part of the user interface is static and which part is dynamic. Boulevard provides the following features to support the user:

Discovering prominent functionality – we proposed a novel algorithms for computing user command prominence. Simply speaking, we consider the most *frequently* used commands as the most prominent. However, *recently* used commands are also considered in order to personalize to short-time usage patterns.

The "Sweeping-back" feature – provides an intelligent organization of semantically similar user commands. Besides the frequency and/or recency of usage, our system organizes user commands in the Boulevard considering semantical relationships also (e.g. "Bold", "Italic" and "Underline" represent a group of related commands).

Adaptive representation – presenting user commands according to the interaction style used to issuing user commands. Presumably, users associate user commands with their visual representation, e.g. "Print" as a toolbar icon with a printer symbol or "New" as a menu item in an upper part of "File" menu category.

Recommending parameter values for user commands – recommending the most frequently and/or recently used values to apply with user commands, e.g. most frequently used colors or font sizes.

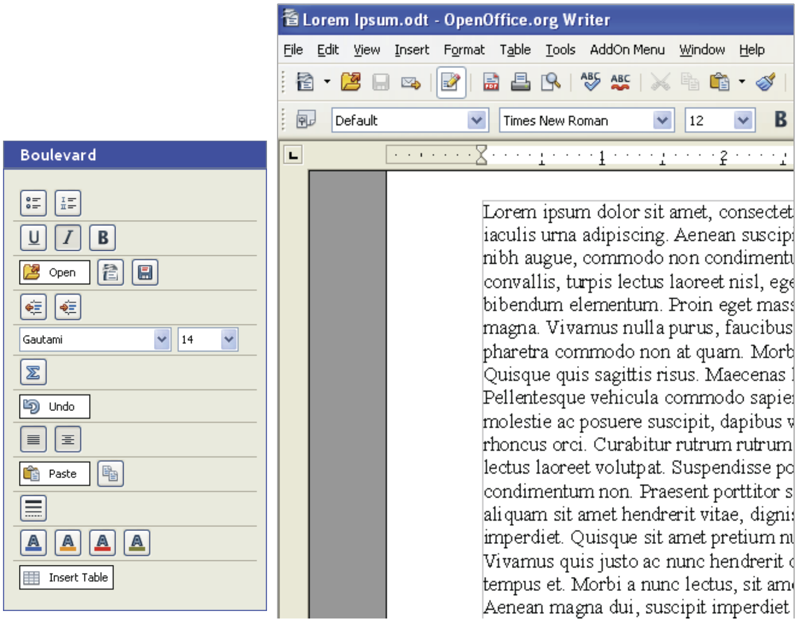

Figure 1. Boulevard in OpenOffice Writer: adaptive panel on the left, Writer window on the right

Adaptive disclosure – Boulevard is able to personalize, apart from the menu and toolbar items, also dialogs. However, only the frequently and/or recently used parts of dialogs are presented.

Boulevard uses dedicated logger for tracking user activity. Logged information is handled by the forward-chaining expert system written in CLIPS, which is a well-known and widely-used expert system shell with a forward chaining inference engine.

We conducted a study to verify the basic concepts of our system [18]. The study focused on task time and error rate analysis measured on selecting particular user commands using three different interaction styles, namely: toolbar, menu and Boulevard. The study provided promising results since Boulevard was found comparable to toolbar in quantitative measurements (although no statistically significant difference was found) and faster than menus. According to qualitative measures, Boulevard was rated as a better interaction style than toolbar and menu by most of the participants. Furthermore, most participants reported that they would like to use Boulevard.

2. Affective Boulevard

The aim of our research is to develop and evaluate an adaptive user interface considering user's emotional state, workload and current point of gaze. We use an EEG headset and an eye-tracker to optimize adaptations of user interface. As main output of our work we expect to demonstrate benefits of knowledge about user's emotional state, workload and current point of gaze in adaptive user interface. For this purpose we use the already developed adaptive user interface Boulevard. In brief, our goal is to enhance Boulevard by utilization of affective computing and eye tracking, since considering users's emotional state and point of gaze may play important role for perception of adaptations in user interface, which is a critical aspect for adaptive user interfaces.

As the primary source for detecting user's emotional state we currently use the EEG headset, however, there are other techniques which we will consider, like analyzing user's face through camera and even utilization of an eye tracker for determining user's emotional state is possible, however, not as precise as EEG (used e.g. in [17]).

We aim to develop a mechanism to automatically improve adaptations in user interface. The Boulevard will detect the user's satisfaction level of previously performed adaptations in user interface and use it as a feedback for optimizing the future adaptations in order to maximize user's satisfaction with the adaptive user interface. Currently, we are running experiments designed to determine which parameters obtained from the Emotiv EPOC Suite are characteristic for particular pattern, when usability principles in user interface are violated. For this purpose we have developed a simple 2D game, which we use as a sandbox for simulating violation of usability, e.g. random inversion of movement control keys, overlap of important area of screen by a non-transparent rectangle and also complete loss of control over the game. We are using such a simple game since our measurement is then not affected by so many various factors as in complex application. Then we will implement such observed patterns and corresponding parameters to Boulevard's expert system which control adaptation of user interface in a real complex application.

Simultaneously, we are working on following features, both are based on detection of the right moment to perform adaptation in user interface:

Proper timing of adaptations from emotional point of view is considered as critical, since we expect an impact on performance, usability and reception of such AUI by the user. For this purpose we are enhancing the current expert system by additional data sources from EEG and developing appropriate rules. The main idea is that we consider the user interface adaptation as less acceptable for user when the user is tired, busy or frustrated. In such situations we consider as better to wait with the proposed adaptation of the user interface for a better moment (when the user is not tired, busy or frustrated).

Proper timing of adaptations in terms of user's point of gaze is also based on proper timing of adaptation, however, current point of gaze from the eye tracker is used, instead of mental state from EEG. We consider adaptation as more acceptable for user if the user's gaze is focused on the panel with the AUI (Figure 1) than adaptation during which the user's gaze is focused elsewhere.

In future, we plan to investigate the impact of animations from emotional point of view. Our hypothesis is that more expressive and noticeable animation of adaptation of user interface is better perceived by the user than a modest one when the user is not busy or tired. In such cases the modest animation will be used.

Particularly for AUIs, real, widely-used software offers a more relevant and promising results in terms of external validity. Limitations of software prototypes have also been discussed in more detail by Thomas and Krogsæter in [20]. Also the need of studying AUIs on a realistic task was mentioned by Findlater et al.[21]. For that reason we are using the already developed suitable research framework for performing user studies on a real complex application, namely OpenOffice.org and OpenERP.

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