A Layout-based Estimation of Presentation Complexity

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ABSTRACT

The complexity of a user interface indicates how demanding its use will be, which is a crucial fact in scenarios where cognitive resources are valuable, such as while driving a vehicle. Detailed research has been conducted on the parameters that can be modified to improve the perception of in-car presentations by the driver. However, less is known about quantifying the impact of a concrete interface. We propose a bottom-up approach for estimating the complexity of the composition of objects on a screen, which can be combined with previous research results. A first version of a formal mark-up is proposed and its upcoming evaluation is described. More results will be available at the conference.

Categories and Subject Descriptors

H.5 [**Information Interfaces and Applications**]: User Interfaces; H1.2 [**User/Machine Systems**]: Human factors—*complexity measures, performance measures*

General Terms

Theory

Keywords

cognitive load, presentation complexity, automotive information systems

1. RELATED WORK

The motivation for our work is the understanding of the relationship between the interface presented to the user, especially in high-demand situations, and the impact on the workload, including distraction from other, potentially more critical tasks. Literature confirms that a distinct relationship exists.

[10] performed two experiments of taxing selective attention processes on the efficiency of working memory processes in relation to normal aging. The results show that the presence of task-irrelevant information disrupted the working memory process, which could be measured to a greater extent in older than in younger adults. In conclusion, it is suggested that distraction disrupts the ability to maintain a coherent stream of goal-directed thought and action in general and should be avoided for in-car presentations.

[8] performed a study aiming at investigating the driver's ability to detect the deceleration of the car ahead, while executing a mobile phone related task. The authors claim that neither hands-free nor voice-controlled phone interfaces could significantly remove security problems associated with the use of mobile phones in the car.

[7] performed a study on the difference between vocal commands and virtual sound cues while navigating without sound. The effects were observed both with and without cognitive load on the subject. Their hypothesis was that sound would cause less cognitive load than spoken spatial commands. No significant difference was found in low-load condition, but significant difference in the high load condition, where the navigation task could be completed in less time when guided by audio cues instead of spatial language. As consequence to the field of automotive research, navigation systems should switch from spoken commands to well known sound cues when the driver encounters high cognitive load.

[9] investigated the effects of divided hearing attention. Subjects were asked to interact with an audio menu, while being exposed to another audio source. Under low cognitive load, the spatial audio technique was preferred and the interruption technique significantly less considered. Conversely on high cognitive load, these preferences were reversed.

While these studies examined certain aspects of the interaction between presentation and user in very specific cases, they do not yet reveal much about the properties of this interaction. Imbeau et al. performed an extensive user study on formal parameters which influence the perception of presented information [6, 5]. In a simulated vehicle, forty subjects were asked to read aloud words presented in eight second intervals on two displays which emulate written legends on an instrument panel while driving at nighttime conditions. The characteristics of the words presented were varied

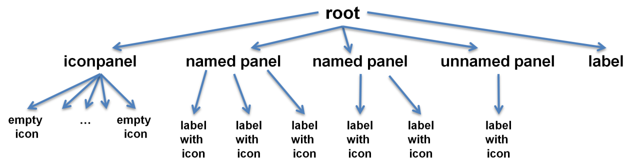

Figure 1: The HMI as component structure tree.

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in four different dimensions and combinations thereof. The variations include word complexity[1], chromaticities, brightness, and character size. The main goal of their work was to "provide designers with integrated quantitative performance data that will help them answer design questions and evaluate design alternatives". Using their model, user responses to various changes in parameters can be predicted "offline". [2] describe an approach to speech-driven UIs for drivers. The authors discuss the impact of linguistic complexity on cognitive load.

2. ANNOTATED COMPLEX. ESTIMATION

The previous literature review clearly indicates that considerable work has been put into analyzing parameters and conditions to streamline and improve the delivery of information to the driver of a vehicle. Especially [6] and [5] probed every conceivable parameter of in-car display design very thoroughly. On the other hand, their work is based on displays of the late eighties, and technological progress did not stop there. While the emphasis back then was on font size, color, brightness, contrast and word complexity, we now also have to deal with sophisticated layouts. Also, the use of a touch screen and virtual buttons on the screen was not considered then. General parameters were in the focus of the research while UI composition was neglected.

Layout is commonly defined as the part of graphic design that deals in the arrangement and style treatment of elements. A programming interface for a user interface, such as for instance Java Swing, provides several types of containers ("layout managers") for the developer to choose from. In defining the Annotated Complexity Estimation procedure ACE, we reverse the top down layout manager process to a bottom up aggregating model of complexities. The nested structure of a user interface can be represented as a tree structure, where each edge represents a container-contents relationship. The main layout manager is located at the root of the tree. Other layout managers may be nested in it. When analyzing the complexity of a layout, we can start at the leaves of that tree and work our may up to the top and accumulate the complexity until we reach the top of that tree. The simplest leaf, or more precise: component, we encounter is for instance a label or an icon. A label has a text of a certain complexity, and it might contain an additional small icon making it more complex. Rudimentary components can be grouped in a panel. The panel has a size in terms of the number of elements it contains, it might have a visual boundary, such as a border line, that makes it easier to perceive as a unit. Panels again might be combined to a higher level panel. Following this combining of elements further, we reach the root of the tree and the component that fills the whole screen. The aim is to find a numerical value describing the visual complexity of that root node. In figure 1, the structure of the HMI is presented as a component tree. In order to apply the ACE procedure, the leaves of the tree have to be annotated with numerical values, and for all non-leaf nodes an aggregation formula has to be specified. In order to automate the procedure, we transform the tree into a machine-readable XML annotation.

An interim consent was achieved as shown in Table 1. It will be the objective of further experiments to determine its

component	basic complexity	feature	added complexity
label	0.1	text=true	+0.5
		icon=true	+0.4
icon	0.1	type=empty	+0.0
		type=icon	+0.5
		type=static	+0.2
		metainfo=text	+0.4
panel	$0 + \sum$ child nodes	decoration=framed	+0.2
		decoration=none	+0.5
		metainfo=named	+0.2
		metainfo=none	+0.5

Table 1: Calculating values for ACE evaluation

validity or learn more accurate projections. Using this procedure, the overall complexity calculated for this example is 9.3. Note that this is based only on structural complexity of the user interface design. In a more refined approach, all the parameters identified in [6] have to be considered as well. We will attempt to verify our approach in an experiment, where users estimate the complexity of given presentations on a scale of 1 to 10. Using a development data set, parameters of ACE will be refined and tested again with a control data set. After showing the general applicability of the approach, we will refine and extend it to more GUI elements and refine it according to the related work presented here. The resulting system will be used in the SiAM system.

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