# A Model For Predicting the Visual Complexity of In-Vehicle Interfaces

Luuk Beursgens
Eindhoven University of Technology
Eindhoven, The Netherlands
l.beursgens@tue.nl

Sandro Castronovo
German Research Center for Artificial Intelligence
Saarbrucken, Germany
sandro.castronovo@dfki.de

Christian Müller
German Research Center for Artificial Intelligence
Saarbrucken, Germany
christian.mueller@dfki.de

Jacques Terken
Eindhoven University of Technology
Eindhoven, The Netherlands
j.m.b.terken@tue.nl

## ABSTRACT

This paper describes the development of a model that can be used to estimate the visual complexity of in-vehicle graphical user interfaces (GUI) and to reduce the distraction of in-vehicle interfaces and thus improve the driving performance. The first version of this model was validated using a GUI that was designed for an interactive C2X application. Using the model, the visual complexity for different screens of the GUI was calculated. 22 participants performed a simple ticket reservation task with the GUI while performing a driving task. A significant correlation was found between the visual complexity and the time until action. Although this result indicates the potential of the developed model, the model has to be refined and further validated in future iterations.

## Categories and Subject Descriptors

H.5.2. [**Information Interfaces and Presentation**]: User Interfaces  -– *screen design, theory and methods*

## General Terms

Design; Human Factors

## Keywords

Visual Complexity, Graphical User Interfaces. Automotive UI

## 1. INTRODUCTION

When designing graphical user interfaces for in-vehicle use, a key consideration should be the impact of the interface on the driver. Currently, no ready-to use tool to predict this impact is available. Although it is expected that multiple factors play a role, this paper considers visual complexity as an important cause for driver distraction. When an interface is visually complex, we assume that the user needs more time to inspect the display and decide upon an action When the visual complexity of graphical interfaces can be predicted, design decisions can be made that decrease the impact on drivers' distraction and performance..This paper reports on the development of a model that predicts the visual complexity of individual, in-vehicle interface screens. Moreover, a first validation of the model is presented. Although the results are considered preliminary, they provide handles for a next iteration in which the model can be refined and validated further.

## 2. COMPLEXITY ESTIMATION MODEL

The complexity estimation model builds on the Annotated Complexity Estimation model (ACE) [1]. During the ACE procedure, interface designs are represented by tree structures. By valuing the different nodes of the tree a visual complexity can be predicted that takes into account element complexity and the complexity of the interface layout. The model that was created during this project uses a similar approach and determines an estimated complexity value for a single interface screen based on six parameters: (1) the number of nodes in the interface's tree structure, (2) the depth of the tree, (3) the overall contrast of the screen, (4) the sum of the complexities of the different geometries, (5) the sum of the complexities of the different words and (6) the number of characters present in the interface. The value for the overall contrast is calculated using the RMS contrast formula [2]. Geometry complexity is based on an empirical survey in which participants were asked to rate the different geometries present in the evaluated interface for complexity on a ten-point scale. A word frequency list [3] is used to determine the complexity of individual words. The complexity of words, as well as abbreviations, numbers and punctuation are also addressed by counting the amount of characters present in an interface screen. The values for all parameters are normalized between 0 and 1 and are weighed by 1 in this first version of the model. The sum of the parameters then results in an estimated visual complexity value of an individual interface screen.

## 3. VALIDATION

The complexity estimation model was validated using a graphical user interface (GUI) that was designed for an interactive Car2X application. The application allows drivers to reserve movie tickets for movies that are advertised on roadside displays.

### 3.1 THE GUI

The GUI supports ticket reservation through a step-by-step interaction dialogue. Social functions, like inviting friends, were also fitted in the step-by step structure. The different screens were designed for fast comprehensibility by using meaningful colors and limiting the amount of information presented to the bare essential. Since the interface was part of a multimodal HMI, the GUI aimed to support users in the speech interaction with the system. Actual touch interaction using the interface should be seen as the secondary modality that can be used in cases that speech in/output might not work satisfactory (e.g. in an environment with lots of environmental noise).

### 3.2 Method

For the validation, three screens of the GUI were selected. The screens allow users to (1) select a data and time, (2) select the

number of tickets and (3) select specific seats in the cinema (Figure 1). For all three screens three versions with different visual complexity were created (referred to as x.1, x.2 and x.3 where x stands for the selected GUI screen). The visual complexity of all nine versions was calculated using the developed model (Table 1).



**Figure 1. A visually complex version of the screen that lets the user select seats (version 3.3).**

All versions were made interactive using Adobe Flash and were combined in three ticket reservation interfaces. The sequences were presented to participants on a 7-inch touch display in a driving simulator. Participants were asked to perform three simple ticket reservation tasks using the three different interface sequences while performing a driving task. The ticket reservation task remained consistent over the three different reservation interfaces. The order of the conditions was counterbalanced among participants.

During this performance test, data concerning driving performance, gazing patterns and interaction patterns were collected. It is expected that a visually complex interface screen will negatively influence driving performance, increase the amount and duration of gazing at the display in the period between the initial presentations of individual screens until the first interaction. Moreover, the duration of this period is expected to be longer if a screen is visually more complex.

A total of 22 students of Saarland University took part in the experiment (mean age = 24.4, 12 male, 10 female). All participants owned a driver license. None of the participants was colorblind or had another condition that could negatively affect their performance during the experiment. In return for their participation, the participants received a fee of 8 euros.

## 3.3  Results

At the time of submission of this paper, only the durations of the screen initiation phases for every screen version had been analyzed (Table 1). Since it was likely that the relation between the durations and the complexity estimations would not be linear, a nonparametric procedure, Spearman's rho, was applied in order to calculate the correlation. Spearman's rho revealed a statistically significant correlation between the visual complexity values that were calculated with the model and the mean screen initiation phase duration ($r_s$ = .717, $\rho$ < .05) (Table 1).

**Table 1. Mean initiation phase durations and calculated visual complexity per screen version**

| Version | N | Duration (ms) | Complexity |
|---|---|---|---|
| 1.1 | 22 | 7869 | 3.388 |
| 1.2 | 22 | 11873 | 2.030 |
| 1.3 | 22 | 13135 | 2.648 |
| 2.1 | 22 | 3710 | 1.270 |
| 2.2 | 22 | 3366 | 1.482 |
| 2.3 | 20 | 7228 | 1.589 |
| 3.1 | 22 | 10378 | 1.866 |
| 3.2 | 22 | 4830 | 0.900 |
| 3.3 | 22 | 11421 | 2.850 |

## 4.  DISCUSSION AND FUTURE WORK

Although these first results are promising and give an indication of the potential of the complexity estimation model, the model should be further refined. By experimenting with the weights for the different parameters that constitute the estimated complexity value, the effect of the different parameters should be determined. Especially the parameters for word complexity and character count might have a substantial influence on the complexity in comparison to the other parameters.

Looking at the qualitative observations by the experimenter during the experiment, there are indications that the contrast of the different elements should have had a more prominent role in the model's equation. Looking at Table 1 the high mean durations for version 1.2 and 3.1 can be partially explained due to the lack of contrast of the target elements. According to the observations and the comments, participants had trouble recognizing some of the elements in these screens as interactive elements due to poor color contrast and transparency.

Further analysis of the driving performance and gazing patterns that were measured during this experiment will provide more insight in the trustworthiness of this correlation.  The collected dataset in combination with observations and comments by participants has provided valuable information for the start of a next iteration in which the model can be adjusted and evaluated. The general effect of any adjustments could be quickly assessed using the dataset that was collected during the experiment for this project. In future validations, a larger sample and more experiment conditions should be tested in order to assess the robustness of the model.

## 5.  ACKNOWLEDGMENTS

## 6.  REFERENCES
[1]  Endres, C. (2012). *PRESTK: Situation-Aware Presentation of Messages and Infotainment Content for Drivers.* Saarbrucken: Saarland University.

[2]  Peli, E. (1990). Contrast in complex images. *Journal of the Optical Society of America , A7* (10), 2032–2040.

[3]  Davies, M. *Word frequency data*. Retrieved August 24, 2013, from http://www.wordfrequency.info.