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# ANALYSIS OF THE VISUAL DEMAND OF TYPICAL DATA ENTRY TASKS IN NAVIGATION SYSTEMS

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**_ABSTRACT_**

*Considering the increase of in-vehicle systems and their potential to distract drivers due the design of their human-machine interfaces (HMIs), this paper presents an application of the method Extended KLM to assess the visual demand of two typical tasks performed in navigation systems. The method provides objective results for the evaluation of design solutions early in the development of in-vehicle information systems (IVIS).*

**_KEYWORDS_**

*ergodesign, usability, driver distraction, visual demand, IVIS, navigation systems, task analysis*

## 1. INTRODUCTION

The advancement of computer technology in vehicle systems has been quite intense in the last years. Nowadays, there are two kinds of in-vehicles systems available: the advanced driver assistance systems (ADAS) and the in-vehicle information systems (IVIS). Although the use of these systems can bring benefits, they must be carefully designed to avoid distractions to the driver in its primary task - driving the vehicle safely.

The communication between the driver and IVIS is usually performed through controls and displays, and in some cases by voice command. In a general manner, the driver enters with their inputs through controls (e.g., push buttons) and receives the information processed through visual displays, thus establishing his communication with the system.

With the emergence of an increasing number of in-vehicle systems, several researchers [Ranney00; Burns00; Lee04] have been concerned about the drivers' safety, as these systems may require a lot of attention while driving. Due to the complexity of using these systems, the authors consider that they may distract the driver, diverting his attention from roadway and increasing the risk of incidents.

According to [Ranney00] the "driver distraction may be characterized as any activity that takes a driver's attention away from the task of driving." However, as the distraction occurs by several sources it is important to understand it in terms of four categories: visual distraction (e.g., looking away from the roadway), auditory distraction (e.g., responding to a ring cell phone), biomechanical distraction (e.g., manually adjusting the radio volume) and cognitive distraction (e.g., being lost in thought).

Considering that the driving task requires the driver's attention to what is happening in front of him, the visual distraction can be considered the category that most occurs, and consequently, the one that can cause more accidents. Wang et al. apud [Burns00] stated that 13% of accidents with vehicles in U.S. were related to visual distraction and part of this could be related to the use of IVIS. [Brooks05] also states that the higher the system's visual demand the more dangerous the driving task.

Aiming to evaluate the visual distraction, primarily related to visual demand afforded by IVIS, several methods have been developed: such as eye glance studies, visual occlusion technique, "the 15-second rule" SAE J2364 [SAE04] and others. Among these methods, the occlusion technique is considered one of the most promising in the study of visual demand afforded by IVIS [Gelau04], since it is relatively inexpensive and not time-consuming to apply and analyze the results.

## 2. THE OCCLUSION TECHNIQUE AND THE EXTENDED KLM

ISO 16673 [ISO07] defines the occlusion technique as a "measurement method involving periodic obstruction of participant's vision or the obscuration of visual information under investigation." This international standard was developed to "provides a procedure for measuring visual demand due to the use of visual or visual-manual interfaces accessible to the driver while the vehicle is in motion", applying to both Original Equipment Manufacturer (OEM) and aftermarket in-vehicle system.

The main objective of the occlusion technique consists to assess the visual demand afforded by IVIS, as well as simulate the interruption of a task performed in the system. This technique is based on the assumption that the driver while driving using an IVIS must balance his vision, alternating between looking the road and reading the system display and controls. From this, in order to simulate normal driving conditions, the technique uses a device that blocks the vision of participants (such as PLATO - portable liquid-crystal apparatus for tachistoscopic occlusion) [Gelau04] at certain time intervals, varying between occlusion and vision intervals at the moment that the participant performs a given task in the IVIS investigated, with the vehicle parked. The occlusion interval simulates the time when the driver would be looking at the road, while the vision interval simulates the time when the driver would be performing a task in the system. ISO 16673 establishes the duration of 1.5-second for both intervals of occlusion and vision.

The main parameters provided by the occlusion technique are: the 'total task time under unoccluded conditions' ($TTT_{unoccl}$), the 'total shutter open time' (TSOT) and 'resumability' index (R). The '$TTT_{unoccl}$' refers to the total time required to perform a task without interruptions, while the 'TSOT' is the total duration of all intervals of vision while performing the task with interruptions and is related to the time that the driver would not be looking at the road. 'R' is the ratio of the duration of 'TSOT' and '$TTT_{unoccl}$' (i.e., TSOT / $TTT_{unoccl}$), which means how easy a task can be resumed after several interruptions. Values of 'R' less than 1 indicate that the task might be performed even at intervals of occlusion – a task that requires less visual demand to be completed.

Although the occlusion technique is considered fast and easy to apply, the tests with drivers required must be carried out with IVISs already developed or with functional prototypes. This prevents the assessment of visual demand of human-machine interfaces (HMI) under development, to select the best design solutions. However, with the purpose of developing a method for assessing the visual demand, related to the use of IVIS, that could be used early in the development of such system and easy to apply, [Pettitt08] developed the Extended KLM method.

The Extended KLM is based on GOMS-KLM (Keystroke Level Model) [Card80], which is a analytical evaluation model that estimates the time of a task carried out by an experienced user; and it is also based on the occlusion technique in order to predict the total time the task is performed with interruptions. In the same way as is carried out in GOMS-KLM, to apply this new model the researcher first decomposes the task into sequences of operators (physical and mental actions), considering the user's goals, methods and selections rules to complete a given task, setting the value of $TTT_{unoccl}$. Once the decomposition is accomplished, the researcher distributes the operators along intervals of vision and occlusion in the same way the task is "partitioned" in the occlusion technique. As a result, the estimated values are obtained for the TSOT (total shutter open time) and, consequently, for the R-value. To distribute the operators along the sequence of intervals of vision and occlusion, the author established three assumptions that defines when an operator (action) can occur at occlusion intervals, thus enabling the evaluation of tasks that may be visually interrupted or not.

For the development of HMIs for IVIS, in order to compare design solutions, the Extended KLM is quite useful, simple and easy to be applied to assess the visual demand afforded by IVIS. With this model, it is possible to evaluate, since the beginning of the development of design solutions, if the new HMI will meet to criteria of task time performance when the vehicle is in motion, like the 20 seconds for TSOT of [SAE04] (vision interrupted method) and [AAM03] (principle 2.1).

## 3. METHODOLOGY

In order to assess the visual demand of three navigation systems and compare their solutions for HMIs, the times of two typical data entry tasks were estimated by applying the Extended KLM model. The two tasks assessed were: 1) set a destination by address, 2) select as a destination the gas station (POI) closest to the current position; and the systems evaluated were: A - NavNGo iGO 8, B - Route 66 Navigate 7 and C - Tomtom Navigator 7. These systems were chosen for being the most popular in Brazil and primarily because they have distinct methods for data entry. The address used in the first task was the same for all systems.

Applying the Extended KLM model, in the first stage the tasks were decomposed in sequence of operators, considering the task goals and subgoals, the methods and selection rules, following the guidelines of GOMS-KLM model. The methods and selection rules used were based on a previously usability testing conducted on the same systems and for the same tasks [Quaresma10]. In the second stage, the operators were distributed along the sequence of intervals of vision and occlusion (1.5-seconds per interval), as demonstrated in the example below (Figure 1), considering the assumptions established by [Pettitt08]. Note that no operators was distributed in the fifth interval of occlusion in this example because, according to the assumptions, the subsequent operators to the last vision interval could not be performed at intervals of occlusion, at this step of the task.

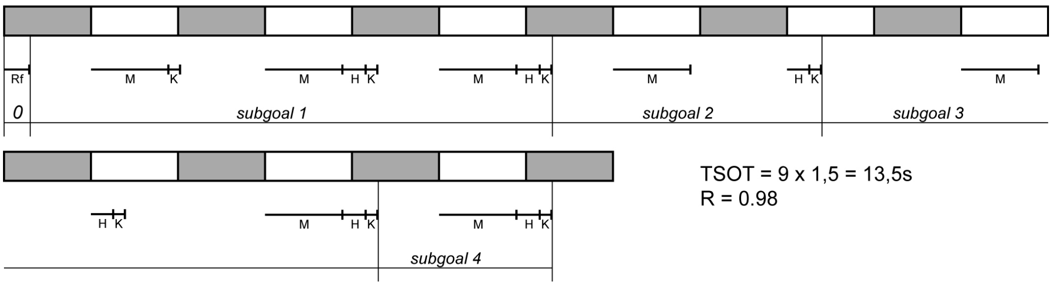


**Figure 1. Example of task decomposition along the sequence of intervals of vision and occlusion (gray rectangles represent the intervals of occlusion and white rectangles represent the intervals of vision).**

With the distributions along the intervals the values of TSOT and R could be estimated for each task. $TTT_{unoccl}$ values were obtained in applying the first stage of the model.

## 4. RESULTS

Table 1 shows the estimated total time for the performance of the two tasks with interruptions (TSOT) in the three systems evaluated, as well as the R-values (resumability), resulting from the application of the Extended KLM.

| | Task 1 | | Task 2 | |
|---|---|---|---|---|
| | **TSOT** | ***R*** | **TSOT** | ***R*** |
| ***System A*** | *19,5* | *0,95* | *18,0* | *0,96* |
| ***System B*** | *23,1* | *1,03* | *17,1* | *1,06* |
| ***System C*** | *19,5* | *0,95* | *13,5* | *0,98* |
| *Systems that meet the 20 s criterion [SAE04] and [AAM00]* | *A and C* | | *A and C* | |

**Table 1. Results of applying the extended KLM method for the performance of two tasks in the three systems evaluated**

In the task 1, it is observed that the systems A and C have the same and the lowest values for both TSOT and R. For system B, the task time is higher when it is performed with interruptions than when it is performed in a continuous manner, as can be seen by the R-value greater than 1. In system B, the problem was related to a list of address (with equal streets names for multiple cities) that the system presents after the address data entry. The steps of address data entry in this system is different from the other two, it is not possible to predetermine the city of the address before entering the street name, in order to filter the database that, consequently, reduce the information presentation to the users. It is concluded therefore that the solutions of systems A and C are the most efficient and suitable for the task performance with the vehicle in motion. Their data entry methods follow nearly the same pattern; each step filters a single information of the address (city, street, building number), facilitating the search for an address in a vast database.

In task 2, the system C presents the best results, with the TSOT value much lower than 20 s and also R lower than 1. The prioritization of the categories of points of interest (POI) is the major reason for the lowest task time, in the system C; the 'gas station' category appears on the first screen of POI categories, whereas in the others two systems it is needed to search this category in long lists in alphabetical order. The system B presents a huge list of categories distributed on twelve screens. Although the system C has almost the same number of categories of system A, it automatically displays on the first screen of POI categories those most used by the user. For that reason the system C presents the best results and this type of solution shall be implemented in navigation systems, to reduce the search of information and, consequently, the visual demand.

## 5. CONCLUSIONS

This paper presents only some results of tasks analysis in navigation systems (IVIS) conducted in [Quaresma2010]'s research. However, the aim was to demonstrate that a simple method, such as Extended KLM, could be very useful for assessing the visual demand of IVIS in the development of HMIs used in vehicles. This model is a practical and fast method to be applied, and provides results quite objective. Despite the model requires careful attention in defining the operators, once learned how to define them, it can be readily applied in the assessment of various tasks in IVIS interfaces. The important point of this method is that it can be applied early in the development of HMIs, where certain design solutions can be compared. Moreover, this method is efficient and inexpensive for a preliminary assessment of visual demand, especially comparing it with other available methods for assessing visual distraction, which require expensive instruments and time-consuming analysis.

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