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A Microscopic Simulation-Based Decision Support System to Develop Changeable Message Sign Alternatives

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Abstract - **This paper introduces the development of a web-based decision support system, to facilitate human factor studies regarding the use of changeable message signs (CMS). A microscopic traffic simulator VISSIM was used to generate realistic simulation scenarios with various CMS alternatives implemented. A case study for truck mounted changeable message sign on an urban multilane highway for "right lane closure" condition was discussed in detail to illustrate the use of the proposed system.**

Keywords - Changeable Message Sign; Human Factor; Microscopic Simulation; Decision Support System.

I. Introduction

Changeable Message Signs are basically used to give motorists real-time traffic safety and guidance information about scheduled and unscheduled events that significantly impact traffic on the highway system. Scheduled and unscheduled activities include advance notifications to the travelers for various like debris removal, pothole patching, natural disasters, snow/ice removal, emergencies, and special event etc. The usage of changeable message signs in various transportation activities like construction and maintenance zones has become more popular and effective in the recent years.

A human factor study is needed to determine the effectiveness of display message alternatives for motorists. The understanding of human factors is important, as it gives an insight of driver's comprehension and preference of the messages, which varies from person to person. Human factors study helps us understand, if the display message is able to communicate the information to the travelers quickly, accurately and timely or not. It also helps in evaluating the preference of words and their display, since poor display or format messages can lead to accidents.

For example earlier research on human factor study of display messages in Texas concluded that flashing a one-frame message and alternating one line of text and keeping the other two lines constant message did not adversely affect drivers recall or comprehend compared to flashing one line of a three-line message, which affected adversely(Dudek & Ullman, 2002)

Various methods have been employed by earlier studies to study human factors. Driver simulator and microscopic simulation models are the most widely used ways in evaluating human factors.

In a study to understand subjects' response to a variety of VMS stimulus messages Wang and Cao (2005) employed a video-based simulation method and found that static, one-frame messages took less response time than sequential, two-frame ones; messages with fewer lines were responded to faster in both static and sequential ones.

Another video-based simulated human factors study to assess the effects of adding graphics to dynamic message sign (DMS) message found that graphic-aided messages displayed in amber or green respond significantly by the subjects. (Wang, Hesar & Collyer, 2007)

Horswill & Plooy (2008) found that vehicle speeds would become harder to discriminate and vehicle speeds would appear slower in another video simulated study to find the effect of reducing image contrast on speed perception.

On the other hand realistically designed driving environment is also a very effective and intensive way to query drivers about all types of traffic control to identify the PCMS effectiveness compared to pen and paper evaluations, as the subject controls the vehicle; the driving simulator's integrated computer calculates several other characteristics in real time. In another driving simulator study to evaluate drivers understanding of display messages on PCMS, researchers concluded that presenting five units of information on Sequential PCMSs will result in substantially lower comprehension rates than if the information is presented at one location on a large two-phase DMS (Ullman, Dudek, Williams & Pesti, 2005).

Guerrier and Wachtel (2001) used an interactive driver simulator to study driver response to variable message signs of differing message length and format and results showed

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consistent and significant age effects across all tested conditions.

Both micro-simulation and driving simulator methods have their own advantages and disadvantages. The advantages of Micro simulated models include risk-freeness to experiment and test assumptions, a means to predict by allowing preview of possible outcomes and a decision-tool to show the effects by means of visualization. In addition to that micro simulation approach allows for a large and significant amount of high-quality data that can be collected quickly in the laboratory or any location with the minimal imposition to the motoring public, who agree to participate in the study. It is also very economical and time saving, when compared to the driving simulator study.

Though driving simulator study has a more practical and realistic approach, this method is not feasible for all the situations due to its high cost to set up the experiment. Also it is not flexible to conduct the human factor evaluation at any other location other than the laboratory. Data collection is also very time-consuming compared to micro-simulation method.

Therefore, micro-simulation method was opted for this research by involving subjects in a real simulated driving environment.

II. Methodology

The simulation process of this project includes four steps-creation of message alternatives, design simulation scenarios, simulation environment set up and video recoding.

A. Design of Display Message Board

For displaying message, a board of 48 inch height and 96 inch wide is used. Photoshop is used to design this message board. Font size and position are modified according to the complexity of each message group. Generally, font size is 24 inch (height) times 19 inch (width). Display board and message alternatives were developed through the use of text or symbol combinations to address motorist information needs by considering space and letter height restrictions for the PCMS in Manual of Uniform Traffic Control Devices (MUTCD) for streets and highways. Sample message is shown in figure 1.

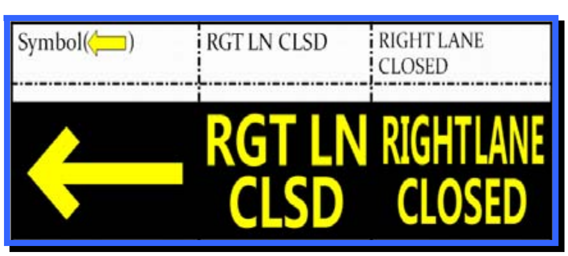


Fig. 1 Image of the Experimental Message Design

B. Design of Simulation Scenarios

VISSIM provides a fast and precise solution for linear time, and system designs, which help us to control the movement of target vehicles, and roadside trailers. Also, its high software compatibility allows us to easily integrate the products of Photoshop and 3D Max. Meanwhile, when the simulation is running, we can switch to the 3-Dimension driver view perspective in which we can discover how the TMCMS operating on the roadway and how the following vehicle react to the presence of the TMCMS i.e. changing their lanes. More important thing is we can simulate various construction scenarios through controlling the speed for the different vehicles such as truck and passenger cars. So, VISSIM was chosen in our project to simulate highway maintenance scenarios in which TMCMS was implemented.

The first step of VISSIM simulation design is model creation which includes design of construction vehicle and message board. V3DM of VISSIM has the function to create those models. The following figure (figure 2) shows the pictures of TMCMS and working truck which were used during our simulation process.

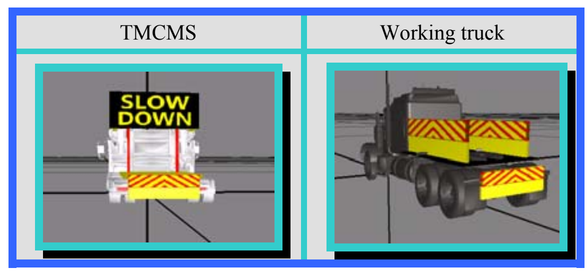


Fig 2. Images of TMCMS and Working Truck

After design target vehicles, realistic simulation scenarios were set up. For example, we need to adjust the lane width, number of lanes, vertical grade, roadside features and so on, to get the desired highway geometric characterizes. Also, for the traffic condition setting, data of traffic volume and percentage of different types of vehicles were input. Some of the specific parameters setting will be discussed in the next few paragraphs about the case study.

C. Set up of the Simulation

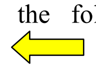
The design of simulation scenarios are based on the different roadway geometric characteristics. For example, for mobile operations in an urban multi-lane highway right lane closed case, the adjusted lane width is 12 ft and a working truck is moving in the front of the TMCMS at the design speed of 5 m/h in the most right lane. Design speed of traveling vehicles is 30 m/h. Message board is placed on top of the following truck. The message alternatives are "  ", "RGH LN CLSD" and "RIGHT LANE CLOSED". One of the 3D driver view perspective is shown in the figure 3.

Fig. 3 one design construction scenario

D. Video recording

The last step is to make recording of the simulation scenarios. The software which we are using is BB Flash Screen Recorder, for it is very straightforward software. In addition, it can produce videos with satisfactory quality. Meanwhile it uses less computer resource which can guarantee that the simulation will run smoothly. The higher quality of the videos, the more accurate feedback we are going to get from the participants.

III. Selection of Scenarios for the Experimental Design

A complete list of simulation scenarios consists of at least 16 scenarios with the consideration of following situations: 1 Urban vs. rural roads; 2. Two lanes vs. multiple lanes; 3. Stationary vs. mobile operations. 4. Truck-mounted CMS vs. traditional message signs. Generally, there are four kinds of messages for each scenario. However, to make all the scenarios justified, some situations may be excluded if unnecessary. (See Table 1)

TABLE 1 SITUATION SPECIFICATIONS

Situation Specifications	
Urban	Rural
Two-lane	Multiple-Lane
Stationary Operation	Mobile Operation
Truck mounted	Traditional Sign

IV. Design of Web-based decision support system

In order to collect the opinions & preferences of display messages of the motorists for the scenarios which we mentioned before, a web based decision support system with multiple choice questions was developed. This system would facilitate decision making process regarding the use of CMS.

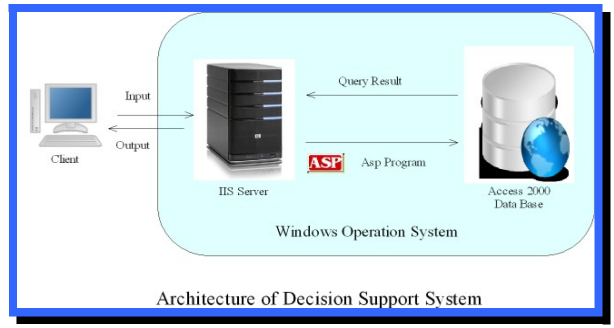


Fig. 4 Architecture of Decision Supporting System

The architecture of the decision support system is shown in figure 4. Users input their comment through the client PC and data will be transmitted to IIS Server, where feedback (user preference) can be ordered and then stored in Access 2000 data base. This system is programmed by ASP programming language.

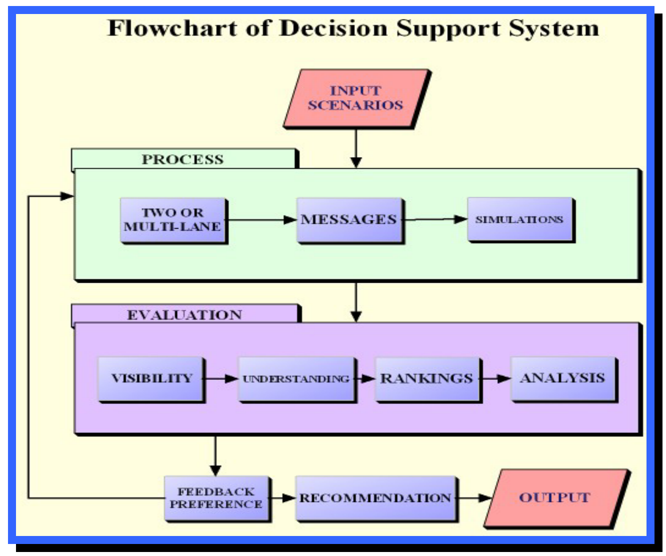


Fig. 5 Flow Chart of Decision Supporting System

The working principle of the decision support system is shown in figure 5. The participants will be asked to answer a few questions and submit their response to the database. The evaluation part is focusing on the questions regarding the visibility and comprehension for each message alternatives. After users input their comments for those questions, the next step is about "preference" where they will decide their preference for those messages.

Figure 6 shows the one user interface of this system. There are four questions (See Table 2) for this case. The first three questions are about the general comprehension for the message alternatives. The fourth question was designed to study the preference factor for the participant to rate the messages as per their preferences. A simulated highway maintenance work zone videos along with the still images of various situations and the question are presented to the participants for their evaluation (See figure 7)

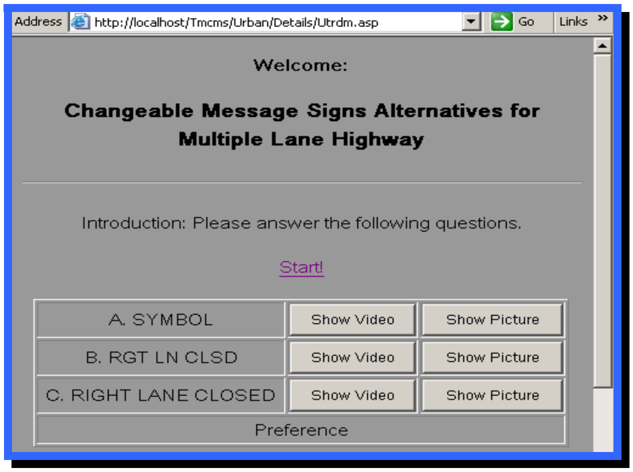


Fig. 6 System User Interface

Fig. 7 Sample User Interface with 3 Videos

The answers of these questions are saved into the database for further analysis use.

TABLE 2 SAMPLE QUESTIONS

	Question Content
1). For the Message: ⇦	What do you understand from the ⇦ " sign shown on the portable equipment?
2). For the Message "Rgt Ln Clsd"	What do you comprehend from the displayed message on the portable equipment?
3). For the Message "Right Lane Closed"	What do you understand from the displayed message on the portable equipment?
4). Preference	Please choose your preference for these three messages.

V. Study Protocol & Data Collection

Four questions are presented to each participant in a sequence along with the simulated videos and an image of the display message. At the beginning of the survey, participants are explained the purpose of the survey and instructions are also given. Participants can watch the video and answer the questions at the same time or can watch the video first and then answer the questions, as there was no time limit set, because the objective was to know their understanding. Participants were asked to select one of the options, which they think would be the best for that particular situation shown in the video. Once the participant submits the survey, responses are recorded in the database.

VI. Data Analysis

A. User Response Summary

A total of 97 (See Table 3) surveys were recorded in the database. Each interviewee rated the different messages/symbols. For symbol (left arrow) message, majority of the interviewees rated the best, compared to "RIGHT LANE CLOSED", which received 54 responses more than half of the responses. After the analysis by using weighted algorithm, we found that Symbol (left arrow) gives the best understanding and comprehension and "RGT LN CLSD" gives the worst.

B. Statistical Analysis

To validate the effectiveness of DSS, we used the weighted average algorithm to analyze the data which was retrieved from the database.

The statistical model used in this study was:

$$T = \sum_{i=1}^{3} \omega_i * \xi_i \qquad (1)$$

Where: T is the overall score of display alternatives
ω is the weight for different choices;
ξ is the number of interviewees.

In this study, we design the survey by ranking the preferences from interviewees, so the weight of different choices is their response for evaluations. It can be learnt from the weighted average analysis table that "ARROW SYMBOL" message is more preferable than other messages as the weight average is the best for "ARROW SYMBOL" which is 1.22, compared to "RIGHT LANE CLOSED" with a weighted average of 2.18 and "RGT LN CLSD (Weighted average = 2.36).

Though the percentage of responses for the abbreviated message is less, few participants believe that it can be a very useful tool because of its shortness and less reading time. Participants also commented that phrase messages are easy to understand as it can be understood by almost anyone without the barrier of language.

VII. Conclusions and Suggestions for Future Work

Based on the case study results of using DSS, it can be concluded that "Arrow symbol" display message is the most preferred message by the motorists compared to the other messages i.e. "RGT LN CLSD" and "RIGHT LANE CLOSED", which is consistent with the preliminary findings of our national phone interview.

TABLE 3. SUMMARY OF DATA ANALYSIS

Message	*Respondents # of*			*Percentage of*			*Total Respondents*	*Total Score*	*Weighted Average*
	1	*2*	*3*	*1*	*2*	*3*			
Symbol(<----)	80	13	4	67.80%	22.03%	10.17%	97	118	1.22
RHT LN CLSD	8	46	43	3.49%	40.17%	56.33%	97	229	2.36
RIGHT LANECLOSED	13	54	30	6.16%	51.18%	42.65%	97	211	2.18

Participants admitted that "RIGHT LANE CLOSED" phrase message is easier to understand compared to its abbreviated version. Microscopic simulated videos were found to be very effective and helpful as various scenarios were visualized to create a real environment. Decision support system will serve as a very resourceful tool for both researchers and practitioners.

A comprehensive list of all the scenarios and situations along with display messages alternatives are being developed in order to create a complete database to make decision making easier for researchers and practitioners. The interface used for the web based survey will be improved to make it more users friendly.

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