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Managing Speed in Inclement Conditions Using an In-Vehicle Interface

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ABSTRACT
This paper briefly describes a system which provides suggested safe speeds for travel during inclement weather conditions. A user study was conducted to evaluate the interpretability of the interface and its effectiveness in influencing drivers' speed choices in inclement conditions. The results indicated that even naïve users were able to correctly interpret interface and adjusted their speed accordingly.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *evaluation/methodology, prototyping, user-centered design.*

General Terms
Design, Human Factors.

Keywords
Speed Management, Interface Design.

1. INTRODUCTION
Crash avoidance and prevention continues to be a vital issue in automotive safety today. Developing ways to meet this challenge using interfaces alone becomes a major challenge, particularly when one considers the many potential causes of a crash. Of particular interest to this paper is reducing crashes due to excessive speed in adverse weather conditions. There were 34,017 fatal crashes in the USA in 2008, of which 284 were due to excessive speed, and 4,034 were due to adverse weather conditions. A cross-tabulation of these accidents showed that 57 were due to excessive speeding in adverse weather conditions, 42 of which resulted from "speed greater than reasonable and prudent, though not necessarily over the speed limit"[1]. Although this is a relatively small percentage of fatal crashes, it indicates a clear subset of fatal weather related crashes that occur not because the driver is exceeding the posted speed limit, but because drivers are making poor speed choices in inclement conditions.

Posted speed limits likely influence drivers speed choices; however, the posted speed limit on most roads in the USA reflects the safe speed *only* in optimal weather conditions. Additionally, research has demonstrated that many drivers do not understand the impact that adverse weather can have on driving performance [2]. Thus, we developed the Speed Limits for Inclement Conditions (SLIC) system to aid drivers' speed choices when the posted speed limit is an inappropriate indicator of safe rate of travel due to either roadway or weather conditions.

2. SYSTEM DESIGN
The SLIC system will use a suite of sensors to collect information about current roadway and weather conditions, including optical sensors, traction sensors, rain sensors, pattern recognition, and global positioning receivers. The information provided by the sensors will be fed into an algorithm to generate a recommended speed range for drivers to travel. The SLIC system will be activated if the system determines that the current road or weather conditions require a reduction of speed below the posted speed limit.

Collecting information via the sensor suite and integrating it to calculate a safe range of speeds is not the focus of this paper. While engineering this system could be accomplished using the technology and knowledge available today, the focus of this paper is the user interface. In order for SLIC to be effective, the speed recommendations displayed by the system need to be intuitive and be compelling enough that drivers' comply with the systems' recommendations. The SLIC interface includes an icon to indicate if the system is active paired with a band of yellow and red bars that overlay the traditional demarcation lines on the speedometer to convey a range of recommended speeds (see Figure 1).

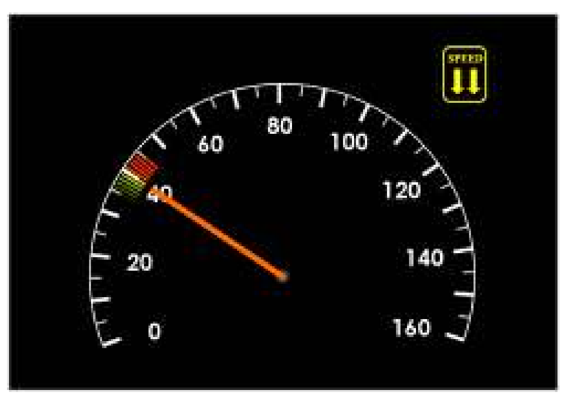

Figure 1. Final design of SLIC interface.

The SLIC interface was designed using a human-centered approach. First, the interface was integrated into the speedometer since effective information displays place compatible display elements in close spatial proximity to one another [3]. A yellow-red color spectrum was used for the recommended speed range since yellow is generally used to indicate "caution" and red "danger", which matches the adverse conditions in which SLIC will operate. Lastly, the SLIC system icon resembles a speed limit sign to help drivers' associate the system display with the desired behavior.

The focus of the current study was to test the effectiveness of the SLIC interface in reducing drivers' speed choices. If the SLIC interface proved effective, drivers would significantly reduce their speed when the system was active compared to when the system was not active in adverse road conditions, even when given no explanation of the purpose of the system.

3. METHODOLOGY

Twenty participants drove a simulated scenario through two different adverse road environments. The SLIC interface was integrated into the George Mason University desktop driving simulator using a Java based programming environment called Processing (http://www.processing.org). A 5.7 mile driving scenario was developed consisting of three roadway sections: a city section to familiarize participants with the driving simulator, a loose gravel roadway, and a heavily wooded roadway with a number of tight turns and a soundtrack that simulated severe, wet weather. The speed limit on the gravel roadway was 35 mph, on which SLIC recommended a safe range of 20-30 mph, and the speed limit in the wet and windy roadway was 45 mph, on which SLIC recommended a safe range of 30-40 mph. On each applicable roadway, SLIC was active for half of the roadway and inactive for the other half – the order of activation was counterbalanced across participants. Lastly, participants were not apprised that the simulated vehicle was equipped with the SLIC system nor were they given information regarding the purpose of SLIC.

4. RESULTS

The SLIC system was effective at reducing participants' speed, suggesting that even naïve users could interpret the meaning of the system. Participants traveled significantly slower when the SLIC system was on compared to when it was off, $t(19) = -9.19$, $p<.001$. Additionally, participants' mean speed was significantly slower within each of these sections. When traveling on loose gravel, participants decreased their average speed by 24.87%, from 40.57 mph (SD = 4.89) without SLIC to 30.48 mph (SD = 6.57) when SLIC was on, $t(19) = -9.52$, $p<.001$. In the wet, wooded section participants decreased their average speed by 7.6%, from 41.47 mph (SD = 5.02) with SLIC off to 38.32 mph (SD = 5.50) when SLIC was on, $t(19) = -3.76$, $p<.001$ (see Figure 2).

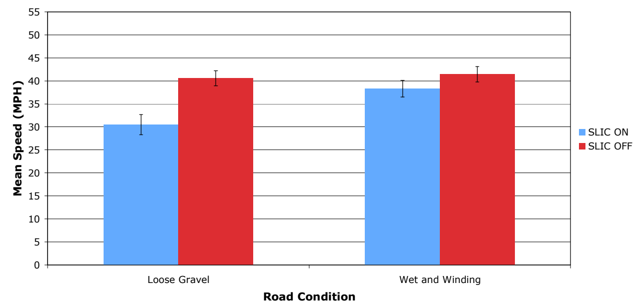

Figure 2. Difference in mean speed by road type.

5. CONCLUSION

The results of this study demonstrate that information imparted by the SLIC interface (i.e. reduce speed to suggested range) is easily interpreted by even a naïve user. Additionally, the interface was successful in modifying participants' speed choices in adverse road environments which has a direct impact on driver safety. One issue to consider is that while compliance with the suggested speed range was excellent, this was in a laboratory with none of the real-world pressures that can cause drivers to increase their speed. While this is a clear limitation of the current study in terms of demonstrating compliance with SLIC suggestions, the issue of non-driving related pressures altering speed is a well established problem for all speed management techniques. When a driver makes the decision to sacrifice safety for getting somewhere faster, there is little that an interface or any other type of speed management technique can do in to force compliance with a safe speed. Ensuring that the interface is easily understood, however, is something that can be controlled and improved. Thus, future usability studies are planned to further test the interface design for the SLIC system.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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