IMPROVING ANALYTICAL APPROACHES FOR EVALUATING VISIBILITY

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Over the last 12 years, the Safety Research Department at Ford has been working more or less continuously on the development of analytical methods for describing driver vision with automobile headlamps in a traffic systems context. These models are based on field-validated versions of Blackwell's laboratory contrast sensitivity curves. The present seeing distance model can deal with a wide range of parameters including headlamp configuration and misaim, target type, size, location and reflectance, road geometry, disability glare effects and backlighting from opposing lamps, ambient illumination, driver attention, driver age and percentile contrast sensitivity level and the reflectance characteristics of wet and dry roads and shoulders. The Ford CHESS (Comprehensive Headlamp Environmental Simulation System) program is a further development of the analystical approach. CHESS uses the Ford seeing distance model to perform a great number of discomfort glare calculations and seeing distance "tests" on pedestrian and delineation targets under a wide range of traffic and driving conditions.

The major benefits of these models are that (1) they make it possible to test and compare beam patterns while they're still in the "drawing board" stage, (2) they can eliminate or reduce the need for field tests and (3) they permit comparisons and evaluations of headlamps under a much wider range of conditions than is feasible even in the most extensive field testing. CHESS also provides a flexible context for incorporating and integrating new research results in highway vision, and for this reason it has a heuristic character.

CHESS's major limitations arise from the fact that the underlying visibility computation is essentially a simulation of a seeing distance test. That is, it is based on narrowly defined and highly simplified contrast detection criteria. CHESS does not deal at all with higher order visual processes and the night driving problems that these processes underlie. These considerations also apply to analytical methods for evaluating fixed lighting or delineation treatments that are based on laboratory contrast detection pardigms. There are two broad problem areas. First, none of our deterministic models deal adequately with the problem of driver attention and how objects of varying conspicuity are "noticed" (as opposed to being detected in the psychophysical sense). The Ford models do incorporate an attention factor in the algorithms that calculate seeing distance to obstacles. But this is based on a single, small scale study performed more than 40 years ago. It would be very useful to have a formulation for estimating the fraction of real world drivers who will notice an obstacle or signal at a given level of conspicuity under various driving conditions. This is a problem that surfaces frequently in applied human factors traffic research. The necessary research is expensive and time consuming, however, because it requires a "one-trial-per-subject" design to insure realistic alertness states. Nevertheless, this is a sufficiently important and general issue to warrant a dedicated research effort.

The second problem area has to do with the higher order visual processes that allow the driver to extract path information and orienting cues from the larger visual context. Under good visibility conditions, these processes are reasonably well explained by contrast detection models applied to the formal delineation elements. However, under more difficult visibility conditions, involving high background complexity, this approach does not suffice. Drivers begin to rely on secondary, informal cues that may be very subtle. Also, orienting cues that are actually well above threshold may go undetected because there is not enough effective "signal" to overcome the background "noise". A useful way to think about this problem is in terms of the influence of background complexity on the delineation conspicuity required for adequate visibility of orientation and path following cues. Although the definitions of conspicuity and background complexity present real problems, they reduce ultimately to physical measurement schemes, and the difficulties are more of a practical nature. Defining what constitutes "adequate" visibility, however, is a less tractable problem.

Simple contrast detection mechanisms are not sufficient to define visual quality. We experience a powerful sense of unease when driving under poor visibility conditions because we find it difficult to organize the visual elements of the scene into orientation and guidance cues. Unfortunately, understanding of the higher order visual processes that underlie this subjective response has not advanced to the point of practical application in a real-world research problem. There is no simple behavioral measure -- such as contrast detection -- that can be applied to measure visual quality in the sense discussed above.

A practical solution to the problem of determining what constitutes adequate visibility is to develop a scale based on driver judgments of visual quality, as determined by conspicuity and background complexity. The advantage of this approach is that it utilizes the driver as a direct sensor, tapping his strong cautionary response to poor visibility without the need to analyze the underlying higher order processes. The research problem is thus to determine the relationship between the objective measures of visual complexity and path cue conspicuity (i.e., the signal to noise ratio) and the resulting judgments of visual quality. This basic approach of relating driver judgments to physical lighting parameters was used by deBoer to develop a scheme for scaling discomfort glare.

Given such a relationship, it would be possible to incorporate it into analytical models such as CHESS to provide a more powerful figure of merit for expressing visual quality in night driving.

VISIBILITY ASPECTS OF ROAD LIGHTING

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Road traffic requires the user to participate by means of his own actions and decisions made on line and based on visual information collected in situ. At night, artificial lighting is essential in order to acquire the necessary visual information. The lighting function is to enable the traffic to function "more or less" as during the day.

The effectiveness of road lighting is expressed in the reduction of the nighttime accidents. For