VISIBILITY IN NIGHT ACCIDENTS

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In accidents at night or in diminished or adverse lighting conditions, the question of whether a pedestrian could be seen, a stopped or slow moving vehicle could be identified, a trailer could be observed when a truck turned onto the road, or a step or wheel stop was visible in a parking garage are questions that arise often. The question is, however, not answered with just a "light meter", a professional or amateur's video or still camera or just going to the accident site. Visibility at night is properly evaluated primarily through contrast and other measurements and an understanding of perceptual issues surrounding the event.

THE VISUAL SYSTEM AT NIGHT

Night accidents are different because, in part, vision under low light conditions is different. Humans can see over a very large range of light intensities and the eye adjusts to existing lighting conditions. Photoreceptors in the eye, cones and rods, play an important role. Their distribution in the retina and an understanding of their response in changing light conditions are critical to understanding vision. In high light levels, vision has the benefit of high sharpness and color. In low light levels, rod receptors become the key players with high sensitivity to light but poor ability to resolve fine details and a loss of color vision. In real world night accidents, vision usually occurs in mixed modes as there is often enough ambient light to blend some operating level of each of the cones and rods. In addition, the clearest imaging that occurs in central vision is significantly degraded at night while peripheral vision retains its relative performance.

As a result, the ambient visual system, which relies on both peripheral and central information and is responsible for spatial positioning with respect to the environment, shows relatively little degradation as the lighting conditions are reduced. The focal visual system, which is responsible for identification and detection of objects in central vision, however, is severely degraded by reduced illumination. Consequently, drivers rely mainly on the ambient system for guidance at night and have a decrease in their ability to extract detailed information from the scene ahead. This can make it difficult to see poorly lit items such as pedestrians, cyclists, and disabled vehicles.

DETECTION

Driver response is a function of detection and perception. The former relates to the information received by the eye, while the second relates to functions such as attention, recognition and conspicuity and decision and judgement. For example, a stopped vehicle on the freeway may not be understood to be stopped although it was visible for many seconds. Furthermore, a visible object may not be "seen" because the driver's attention is occupied elsewhere.

In a night visibility evaluation, the first step of the analysis is typically to determine when the object can be detected. One of the most important parameter in establishing whether a pedestrian, an object or a feature is visible at night is discernable contrast. Contrast is the characteristic of "how readily an object will appear distinct from its background." Contrast is more important than the amount of light. The amount of light can be low, and yet contrast may be sufficient to see a stairway because the light reflected from the risers and the treads are different, thus creating sufficient contrast to see the steps.

In reconstruction of an accident, contrast can only be measured accurately after the accident site and environment have been recreated to reflect the accident conditions. This can be achieved by matching the weather conditions and time of day in addition to the moon position, for example. The vehicles involved in the accident or exemplar vehicles can also be used at the accident or similar site to complete the setting. A pedestrian's clothing needs to be duplicated as well and, of course, the position of the pedestrian or vehicle at a given point needs to be reconstructed.

Luminance is a measure of the light reflected to the eye by a surface. In a pedestrian accident, the amount of light reflected by the clothing of the pedestrian as opposed to the light reflected by the background is a measure of the contrast between the two areas. At night, in order to be detectable, the luminance of the clothing of the pedestrian must be perceivably greater or smaller than the background's, thus resulting in positive or negative contrast. Luminance can be measured with a calibrated high precision luminance meter which allows single successive measurements at different locations. Calibrated luminance imaging photometers are also available that "image" the luminance of a scene, and thus capture multiple luminance measurements at once.

Contrast is then a measure of the difference between luminance values. Determining if the contrast is high enough is the next step and involves accounting for factors such as form, the age of the viewer, the object size and/or distance and the observation time. Glare from oncoming vehicles, the sun or background lighting may also play a critical role in detection. At the right angle, glare will reduce the ability to see an object, person or feature. To account for glare, additional measurements can also be performed at the scene. Factors such as location in the field of view, adaptation and viewer expectation must also be taken into consideration. Finally, factors such as drug and alcohol use as well as eye disease need to be considered.

The steps described above are part of a scientific and thorough evaluation of detection in night or low level lighting accidents. It should by now be evident that the use of a "light meter" alone, which is designed to measure the amount of light as opposed to the reflected light, may not be sufficient for this evaluation. Going to the scene to simply "look" is also insufficient, as the age of the observer and the characteristics of his or her eyes play important roles on the outcome, and there is no independent quantification of the process for others to duplicate or evaluate. Similarly, a video or digital camera, with its many automatic compensating features and functional and imaging differences with the human eye, may not properly capture information at the scene and can be misleading without proper foundation. A discussion of night photographic and videographic methods is, however, beyond the scope of this article. A combination of measurements, a quantitative evaluation and an analysis including all relevent factors, is the only way to scientifically evaluate the ability to detect an object, a person or a feature while properly documenting the steps in the process.

PERCEPTION

Detection is only an early step in a full evaluation of driver response at night. "The input of sensory organs (eye) combined with analysis and interpretation in the brain yields what [is called] perception." It is hence important to understand the various processes and difficulties that can be encountered. In the example of a disabled vehicle on a freeway at night, to avoid a rear accident with a slow or stopped vehicle, an approaching driver must recognize not only that a vehicle is ahead, but also that a collision is imminent. The first task is reasonably simple, as taillights or reflectors can usually be detected (by alert drivers) at distances far beyond the minimum required to avoid an accident. More difficult to judge is the speed of closure with a vehicle ahead. Visual information provided as the vehicle "sweeps across" across the background, such as poles, trees, signs or other terrain features, is largely unavailable at night due to lack of background light, especially in rural settings. Therefore, to determine the speed of the forward vehicle at night, the driver depends on cues based on the visual angle between his eyes and the leading vehicle taillights or reflectors.

If the driver detects that this angle is increasing, this provides information that the driver is approaching the object ahead. The rate of expansion of the size of the object is another cue. Unfortunately, when a stationary (or barely moving) object the size of a car is several hundred feet ahead of a following vehicle, the lead vehicle's visual angle does not expand rapidly. Observers, therefore, have difficulty in detecting whether or not the rate of expansion is positive. Therefore, if the object is detected only by cues based on the rate of visual expansion, the driver is approaching the limits of his/her capability to avoid a collision. Objects, whose sizes are relatively small, such as motorcycles, and even small vehicles, offer even greater difficulty when approached at a relatively high speed, since the threshold of the rate of visual expansion will sometimes be exceeded only when the following vehicle cannot avoid striking it.

Thus, conspicuity alone, if defined as the property of an object to call attention to itself, is not sufficient. The driver needs to understand what the other vehicle is doing relative to him. Seeing the vehicle, in this case, is not the problem; recognizing that it has stopped is the crucial issue, which is based on an understanding of human visual limitations.

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