the intensity distribution of the test luminaires (J-table) and the detailed reflection properties of a test road surface (r-table), together with positioning of lighting columns and road layout to calculate the luminance pattern which would appear in front of a driver.

The limitations of the standard program are that it provides only numerical output, is not interactive, and has limited viewpoints. The advantage is that correct and detailed luminance patterns are calculated.

The first stage of combining these two programs required the modification of STAN to an interactive form, and then using its output as input for VIGIL, to define the luminance of patches of road surface. It was not found possible at this stage to draw perspective views within the interactive program, but plan views were made, with the luminances shown as from the driver's position. A perspective view could be produced quite quickly outside the main program, once the values of spacing, overhang, etc. had been decided.

To draw the screen color and luminance correctly, it is necessary to calibrate the TV monitor photometrically. Fortunately, the non-linear correction required between calculated luminance and video voltage can be easily applied through the use of a look-up-table (LUT), linking the values written in the digital image store with the TV display.

The limitations of the combined system were the viewpoint constraints of STAN, the "tiled" appearance of the road surface, columns were not included in the luminance calculations, and glare was not portrayed. Also, since STAN calculates only one lighting span, the display "cheats" by showing the same span at various distances, and is thus limited to long straight roads only. The advantage was that it provided a quick visual output for a visual problem.

A new program (VOSCO) is now in use which eliminates most of the disadvantages previously encountered. The viewpoint is unlimited, the tiles are shaded, and the luminance and color of all parts of the scene are calculated (including columns, houses, trees, vehicles, pedestrians, etc.). Any shape of model is possible, including large areas of landscape produced from aerial survey, with constructed objects added. The only disadvantage seems to be that it does not yet use J-tables for luminaires or r-tables for road surfaces, so the nighttime road luminance calculation is not as good as the CIE program. However, for the situations where this system is at its best, say for designing lighting for complex junctions, the exact luminance levels are not so important as the overall pattern of luminance produced by placement of individual lights.

The user requires no knowledge of any computer language, or operating system, as the program is "command" based, with easily understood names, and "help" available at all levels.

Some idea of the modeling realism can be gained from a description of how the lighting of a model is defined. For daylight, a sky is used, consisting of the sun and the sky itself. The position and intensity of the sun is determined by the latitude, time of day and month of the year. Each of these can be set by a simple command, which not only sets the sun in the correct position, but also calculates the sky luminances, according to the CIE clear sky distribution. The CIE overcast sky distribution is also calculated, and a weighted mean of the two formed according to the amount of cloud cover, also set by a simple command (e.g., !CLOUD[0.4]). There are also objects called /SUN and /SKY, which may be drawn and show behind any other scene.

The program is completely interactive, producing new perspective views very quickly, and allowing both construction and modification of models held within the data base, so that new models and alterations are easily visualized. Future expansions are expected to allow the use of J and r-tables, and to calculate the effect of retro-reflectors, glare and atmospheric haze.

MEASURING THE VISUAL COMPLEXITY OF NIGHTTIME ROADWAYS

Vincent P. Gallagher, The Design-Eye Group, Philadelphia, Pennsylvania, and
Neil D. Lerner, COMSIS Corporation, Wheaton, Maryland

The research described here was sponsored by the Federal Highway Administration and concerns the difficulty of interpreting complex nighttime road scenes. Subjectively, sometimes a driver's view of the road ahead is more difficult to interpret or utilize than at other times. Cues to the path ahead may be low-contrast, diffuse, or ambiguous. Additional elements of the scene may complicate the visual information processing problem: concepts such as visual noise, clutter, information load, and complexity have been applied to this issue. We describe an effort to measure and model the visual difficulty of the view ahead for the motorist.

It is difficult to describe adequately the visual "signal" and "noise" for the driving scene. A motorist is confronted with the task of identifying, abstracting, and structuring relevant information from the scene ahead of him. Information arrays are both spatially and temporarily arranged. These include diffuse and informal cues, as well as purposeful elements such as lane delineation or signs. Much of the information in view may be irrelevant for driving, and even that which may be considered relevant is not immutably so. The relevancy depends on the transient needs of the viewer. Once utilized, an information element may become functionally irrelevant and even contribute to the background noise against which subsequent information must be identified. Informal delineation, such as roadside foliage, luminaires, other traffic, building lines, etc., may serve as useful cues to path features, but may also contribute to the complexity of the scene. Information elements important for inexperienced drivers, or those unfamiliar with the road, may be unimportant for experienced or familiar drivers. All of these issues indicate the problems of objectively specifying where the view ahead is visually demanding for the driver. Yet being able to identify problem areas would be an important aid to improving road safety and directing countermeasures.

In this project we conducted a number of laboratory studies on the difficulty of driving scenes; we developed a preliminary mathematical model to capture aspects of scene difficulty; we conducted controlled field measurements; and we are currently developing a field-based system to capture and digitize scenes and apply the model.

The five laboratory studies all used photographic slides of behind-the-wheel driving views. These experiments evaluated subjective difficulty, viewing time, and eye movement, using a number of different experimental procedures. The various measures all intercorrelated substantially. The subjective judgments of "how difficult a view is for driving" were especially effective measures, showing good agreement among subjects, a high degree of replicability, excellent agreement between different methods, and accounting for nearly half of the variance in the data.

The scene difficulty judgments were correlated with a formal model of scene complexity, which we term an "instability" model. The model is relatively simple. It does not attempt to isolate or identify individual scene elements, or the structure or organization of the scene. The image is analyzed globally, and the logic is based on current perceptual research on visual analysis of information at different spatial frequencies. Low frequency components may be processed more rapidly and provide the gross information on general form; they are more resistant to many forms of visual degradation, including defocus. The resistance to defocus, or stability of the image, is a function of the spatial frequency and the degree of contrast.

A mathematical model of the potential information loss through defocus was developed wherein the term "contrast" is used to describe the luminance gradient within the scene and the "complexity" is the second derivative. The images, actually photographic transparencies, are first digitized to convert the image from the continuous tone of the photograph to a matrix of gray-scale values. These values are differentiated both horizontally and vertically. In the particular model described here, a composite measure of contrast and complexity, which is the amount of complexity per unit contrast, is viewed as the critical measure. This is termed the instability score.

In applying this model, the original matrix of the digitized image was compressed by averaging blocks of pixels, analogous to low pass filtering. Weighted combinations of the "instability" measure at different compressions were used to yield an overall index, which was correlated with the subjective ratings of the scenes. Various combinations of compressions yielded multiple-R values of from 0.83 to 0.87. Given the preliminary state of the model, these correlations indicate surprisingly good prediction.

A detailed analysis indicated that the subjective ratings appear highly influenced by the low spatial frequency aspects of the scene. This probably relates to gross roadway contour, alignment, and roadside features. The complexity expressed by the instability model is non-intuitive and does not necessarily relate to a subjective impression of "clutter". Ease of gross path identification apparently contributes more than the presence of many objects.

In the current phase of the project, we are developing a system for more efficiently capturing and analyzing scenes with the model. In the previous work, we had to rely on a multi-stage procedure of photographing scenes, developing slides, digitizing the photo-images through an outside service, and transferring the data to our computer for analysis. Such a multi-step process leads to delay and opportunity for noise, error, or miscalculation. It is not flexible for field use in easily identifying sites of interest. The system we are now developing is a micro-computer-based system using off-the-shelf components and video recording. It should provide a more flexible, timely, and cost-effective system, facilitating use of the instability model or other image-analysis methods.

DAYTIME CONSPICUITY OF ROAD TRAFFIC CONTROL DEVICES

S. E. Jenkins and B. L. Cole, Australian Road Research Board, Vermont South, Australia

The paper addresses the concept of conspicuity, how it can be measured and the means by which the daytime conspicuity of traffic control devices can be enhanced. In the road environment there is an enormous influx of visual information with which the driver has to contend. It is essential that priorities be allocated to this information so that the driver directs his attention to only those facets which are necessary for his purpose and safety. Some degree of pre-attentive processing of all information must occur so that the important information is not discarded but progresses to the stage of consciously being used. The information which the traffic engineer wishes to convey to the driver must be conspicuous, legible and comprehensible at this pre-attentive level of processing. Conspicuity is then an attribute of an object within a visual context which will ensure that its presence is noticed at the pre-attentive level of processing. Engel (1976) distinguishes between "sensory conspicuity" -- the degree of visual prominence afforded to a sign due to its crude sensory features -- and "cognitive conspicuity" which arises from the object's meaning, novelty or relevance and will be dependent on the psychological state of the driver, his purpose and expectancies at the time.

Two methods of measuring conspicuity have been developed at the Australian Road Research Board and Melbourne University. One is a laboratory method (Cole and Jenkins, 1980) derived from an operational definition of sensory conspicuity which states that a conspicuous object is one that will for any given background be seen with certainty ($p > 90$ percent) within a short observation time ($t = 250$ ms) regardless of the location of the object in relation to the line of sight. The other is a field trial (Hughes and Cole, 1983; Cole and Hughes, 1984) which uses a verbal report method which must include both sensory and cognitive conspicuity as well as observer variables. In the field trials the level of attention of drivers was manipulated by using two different instruction sets which enabled two aspects of conspicuity to be investigated; "attention conspicuity" which is the capacity of the traffic control device to attract attention when the driver is unaware of its likely occurrence, and "search conspicuity" which is the ability of the traffic control device to be quickly and readily located by search.

Conspicuity can only be discussed in the context of complex backgrounds. If the target is in a uniform background then we must speak of its visibility. To talk of conspicuity the target must have to compete with other objects for the attention of the