C56 Computer-Modified HD-Video Allows Extension of Previous Range of Visibility Studies While Applying Accepted Foundation Procedures

Paul Kayfetz, JD, PO Box 310, Bolinas, CA 94924*

The objective of this paper is to report on the integration of improved video and related computer technology into existing, long-accepted visibility study preparation and presentation methodologies. The result has been an incremental extension of the types of visual environments which can be reproduced with substantial similarity for admission as visibility evidentiary exhibits in court.

This presentation will impact the forensic community and/or humanity by demonstrating that the improved video technology allows a much more accurate depiction of an extended range of visibility conditions that may be encountered during incidents under investigation or in litigation.

Visibility studies — depicting what is available to be seen by a driver (or other witness) with normal unimpaired vision under conditions similar enough to those obtained at the time of the subject incident to be relevant — have been routinely admitted in evidence in state and federal courts throughout this country since the 1960s. Proper foundational expert testimony details basic information such as the proper viewing distance for a life-size image and correct angular perspective; analyzes the significance of such factors as expectancy, the average human horizontal angle of view compared to that presented in the visibility study, and presents a discussion of any similar factors. There have been many articles published concerning visibility study methodology; a coordinated set of presentations appeared in the peer-reviewed abstracts of the 11th Meeting of the International Association of Forensic Sciences in Toronto in 1987 at which three experts in human factors psychology, reconstruction engineering, and engineering photography made presentations regarding the accepted methodology for preparing and introducing visibility studies in evidence (1,2,3).

The methodology for preparing visibility studies evolved steadily through the direct collaboration of engineers and scientists in several fields, along with independent work by numerous others (See *e.g.* Klein *et al*., 4). A great deal of this work related to the methods and related technology for depicting visibility under nighttime or other reduced visibility circumstances in a manner which would be routinely admissible as evidence in court. The methods for accomplishing accurate nighttime films, which have resulted in routine admissibility of such visibility studies were developed on a case-by-case basis with engineering photographers Paul Kayfetz, Michael Mayda, Bruce Kayfetz and others working with human factors psychologists Dr. Albert Berg, Dr. Slade Hulbert, Dr. Herschel Liebowitz, Dr. Kenneth Ziedman, Dr. Robert Post, Dr. Richard Olsen, Dr. Paul Olson, Dr. Thomas Ayres along with lighting experts such as Michael Janoff and Eugene Farber (5,6,7).

The accepted foundation method for calibrating nighttime visibility studies involves controlled observations at the scene being compared to exemplar 4x5 color Polaroid photographs which are annotated for observed levels of detail, and then used as controls for producing and verifying the level of detail depicted in the relevant areas of the final visibility study under courtroom viewing conditions. This methodology has been described in peer-reviewed literature by a range of engineering photographers, reconstruction engineers, and human factors psychologists who have been involved in developing or utilizing the technique.(8,9,10; also 4) This represents a huge advance over the traditional practice of the past century in which a photograph was normally admitted based on the testimony of the photographer that “it is a true and accurate representation of what I saw.”

In the 1980s the author worked with ophthalmologists to adjust visibility studies made using film to depict measured reduced levels of visual acuity. An example which the author prepared involved a motorscooter operator with previously-measured 20/200 vision whose passenger had 20/400 vision. A nighttime 16mm motion picture visibility study was prepared illustrating visibility for a motorscooter operator with normal unimpaired vision striking the side of a slowly-moving freight train crossing his path. Working with the ophthalmologist co-expert, the image was then degraded to depict respectively the vision of the motorscooter operator and his passenger (using a Snelling chart which had been filmed for calibration). This was repeated with a film which had been taken with additional warning devices added at the railroad crossing to show what effect, if any, these would add in warning a driver with this level of vision at night that he was encountering dark box cars across his path. The entire study was routinely admitted in evidence in a California court. Modifications of this type to visibility studies were limited in scope because of the relatively limited alterations which could be made to *film* in a controlled, quantified manner.

Motion picture film and still photographic film were the most technically usable media for visibility studies until significant improvements in *video* which became available only in the past year. This is because 16 mm film has more than 25 times the pixels (resolution units) than does VHS video. Recently, however, HD-video became available in camera configurations which could be used for taking visibility studies in the field. This format has the same pixel count as 16mm film, but appears much “sharper” because there is no apparent grain. (This difference is extremely significant in nighttime applications where highspeed 16mm film has a distracting grain pattern).

The primary conclusion of this paper is that the improved video technology (HD-video systems) allows an extension of this previously-practiced interaction between the visibility study preparer, other experts and eyewitnesses to depict more accurately an extended range of visibility conditions encountered during incidents related to investigation or litigation.

When HD-video is being taken, a waveform monitor can be employed which allows calibration of brightness ranges and color ranges and quantified control in all areas of the image. Once in the computer, extremely precise programs are available for measuring and adjusting densities, brightness, color ranges, and other parameters overall, locally frame-byframe or pixel-by-pixel. The level of control that is available with various programs to adjust lighting or to depict atmospheric conditions is unlimited. The result is that with proper foundational input and controls, using eyewitnesses or experts for validation, conditions prevailing at an original accident scene can be replicated more precisely than with the previous purely-photographic tools.

Four examples of visual situations shown briefly during the oral presentation of this paper will illustrate its objective:

1. *Fog*: During daylight hours a passenger car was proceeding in dense fog reaching to and moistening the ground. The car struck the side of a tractor/trailer pulling forward from a stop sign across the path of the car. Immediately after the collision the driver of the big rig, standing at a known position on a traffic island, took a series of photographs looking down the length of his rig with a series of signposts showing in the photographs. The rear of his rig and certain of the signs disappeared in the fog at ascertainable distances. The police, who arrived within minutes, backed away from a particular sign along the path of the striking car and measured that it disappeared in the fog at 120 ft.

HD-video was taken with a 90 degree horizontal angle of view from the driver=s position in an identical car on a sunny day following the path leading to collision. Separately, a topographic survey of the intersection and the approaching highway was used to create an accurate scale “universe” of the accident scene in the computer. A three-dimensional scale model of the particular big rig involved in the accident was built in the computer and rendered photorealistic using photographs of the accident vehicle. A threedimensional “fog program” was then used to generate the same density of fog as measured by the investigating officers and corroborated by the accident-time photographs. The drivers-eye HD-video was “cameramatched” frame-by-frame with the computer universe of the accident scene using a program which photogrammetrically tracks dozens of landmark features appearing in the video. The big rig was caused to accelerate in the computer from the stop sign through the point of impact as the car arrived at collision, consistent with both the reconstruction analysis and crash tests done by various experts involved in the case. The resulting drivers-eye visibility study showed the fog-filled scene through the entire front windshield substantially-similarly to that measured and photographed by witnesses minutes after the actual accident.

2. *Sun glare*: The author was requested in June to prepare a visibility study for trial in a few weeks. The issue was a driver’s visibility of a pedestrian with the setting sun on the horizon just behind him in a December accident in a parking lot. HD-video was taken at the accident location with the June sun still high overhead on the collision course with an exemplar pedestrian. Hours later the setting sun was videoed at the accident altitude (on a path adjusted at a 50 degree angle to the north) traveling at the same speed in the same parking lot. The exemplar pedestrian again was walking at the same respective angle to the car on the collision course. Portions of the two videos were combined in the computer so that the buildings, hills and other fixed features of the original accident were preserved, but the glare on the windshield and hood, reflections on the pavement, and the lighting on the pedestrian with the December sun position on the horizon directly ahead of the car were accurately depicted in the final composite. The foundation testimony for admissibility included not only testimony from the experts preparing the visibility study, but that of the investigating police officer who drove the same route two minutes after the accident and wrote in her report “the glare was so strong that at 5 mph I almost struck the people standing over the body.”

3. *Smoke and flames*: A wind-driven grassfire adjacent to an interstate highway was a factor in multiple collisions and deaths. An issue was the appearance of the fire and smoke to approaching drivers in different vehicles, at various times over several miles. Lines-of-sight over a crest on the approach were an issue.

HD-video was taken from several exemplar big rigs, a school bus, and a witness truck approaching the fire/collision scene on the paths and at speeds consistent with witness testimony. Video was also taken from each illustrating moderate deceleration to a stop on the shoulder after topping the last crest before reaching the fire. Video was taken from numerous witness= positions looking at the fire area from various directions.

A three-dimensional Auniverse@ compositing the huge fire and smoke plume as it progressed across many acres and during some ten minutes was prepared; (the size of the file was more than 100 gigabytes!). It was based on an extremely high-resolution set of aerial photomaps; aerial and ground photographs of the burned area; extensive topographic surveys, three still photos showing the smoke and flames; photogrammetry locating the flame front, smoke position and height; field sampling, fuel testing, computer modeling, and a fire/smoke progress report by a fire scientist; and the integration of information from written statement and deposition transcripts of dozens of eyewitnesses who viewed the fire and smoke from different directions.

The elegance of the three-dimensional computer universe of the fire/smoke is that any viewpoint can be “dialed in.” The view from a witness’ position can be rendered, the resulting moving video image shown to the witness, and the entire universe modified if necessary based on the response. This process can be repeated with various witnesses until a consensus universe still consistent with the physical evidence is achieved.

Once the computer universe has been conformed to the physical evidence and the best consensus of witness= testimony, the driverseye HD-

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videos are composited with the computer universe of the fire/smoke to show photorealistically what it looked like to a given driver at the time he was approaching from seven miles away and driving into and through some quarter-mile of smoke and adjacent flames. Video-fire/smoke composites from various witness viewpoints, along with related still "video captures" also assist in foundation testimony for admissibility.

4. *Horse vision*: A race horse bolted while being exercised on a track and ran at full speed into a green fence against green foliage under subdued, early morning lighting. HD-video was taken from the horse's eyelevel traveling on the path that he had been following. HD-video still footage was also taken at measured points along the path. From these points HDvideo still footage was taken of color and grey scale charts. These were computer-modified with a computer algorithm by an animal vision physiology professor who has analyzed and tested equine spectral and acuity visual response.(11) His computer modifications of the HD-video color chart and still frames provided a guide, when followed quantitatively with the calibration devices available in the HD-video computer processing programs and equipment, to conform the visibility study moving video to the professor's analysis of what a horse would have seen following this path under these lighting circumstances. Additional HD-video exhibits were then prepared inserting, with identical adjustments for "horse vision," various white warning rails and other safety devices which racetrack design experts testified should have been in place on the fence in order to show they would have been visible to a horse.

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Visibility, Photographic Simulations, Computer Simulations

 ** Presenting Author*