2019 CLM Midwest Conference
June 20 -21, 2019
Chicago, IL

The Forensic Engineering Analysis of Surveillance Video:
A Real-World Example

Abstract:

In today's society where video is routinely captured by phones, surveillance cameras, vehicle cameras, and other sources, the ability to translate video information into data for use in a forensic analysis is critical. The presentation, using a real-world, adjudicated, pedestrian/motor vehicle collision event, will systematically review the data required to complete a proper three-dimensional analysis; the sources of the data; the manner in which the data needs to be collected and processed; the software required; the expected accuracy level of the analysis; and how the results of the analysis can be presented to the trier of fact. This presentation will demonstrate how the video is "corrected" to remove the curvature from the lens; how the video is camera matched within an accurate, three-dimensional environment; how objects within the video are "tracked" within the environment; and how the combination of these processes combine to create an accurate, three-dimensional environment illustrating the movements defined in the video from which speeds, spatial relationships, and sight distances can be evaluated.

General Outline:

I. Collision Event:

The collision in question occurred during the daylight, on a weekday, in the downtown of a center city, urban area. The collision involved a package delivery truck and a pedestrian. Specifically, the package truck, which had been facing northbound, was executing a right turn to head eastbound when it contacted with the pedestrian who was crossing the east approach of the street that the package truck was attempting to access. The video shows that the pedestrian was southbound and just prior to the collision, turned around to head back northbound when the collision occurred.

The front of the package truck struck the left side of the northbound pedestrian. The collision occurred during the daylight, there were no adverse weather conditions, and the roadway was dry. Portions of the movements of the pedestrian, package truck, other pedestrians, and other vehicles were captured on two surveillance video cameras located north and south of the collision area. One camera was located on the building on the northeast corner, and that camera was facing southbound. The other camera was located on a building on the west side of the northbound roadway but was located over one-half block south of the intersection where the collision occurred. This camera was facing northbound.

The collision occurred at a signalized intersection in the center of an urban business/shopping district. Prior to attempting to execute its right turn, the package truck was stopped facing northbound in the right lane of a one-way, two-lane roadway. The package truck was stopped at a red traffic signal. Prior to the collision, the pedestrian was walking southbound along the east sidewalk of the same one-way, two-lane roadway. The pedestrian was crossing the cross street, a one-way, two-lane roadway oriented eastbound, when the collision occurred. The roadways were straight and level, and their intersection was controlled by traffic signals. The specific collision event occurred when the initially southbound pedestrian was contacted by the front of the right-turning (north to east) package truck.

As a result of the collision, questions arose relative to the specific dynamics of the collision (speed and movement of the pedestrian and package truck); the timing of the traffic signal relative to the movement of the package truck and pedestrian; the sight distance available to the package truck operator (should he have seen the pedestrian and if so, for how long); the ability of the package truck operator to avoid the collision; as well as other questions with regard to the actions of both the pedestrian and package truck operator. It was determined that many of these questions could be answered if the movements of the pedestrian and package truck could be accurately reconstructed within a to-scale, three-dimensional environment. By doing so, the actual movement of the package truck and pedestrian as well as specifically what the vehicle operator could see could be replicated and evaluated.

II. Collection of Field Data

The analysis of the video included "camera-matching" the view of the cameras within an accurate, three-dimensional environment (TDE). This required the proper collection of data to create the TDE. This was done utilizing High-Definition Surveying (HDS) laser scanners and Unmanned Aerial Vehicles* (UAVs – a.k.a. drones). The HDS laser scanning included three-dimensional measurements of all buildings and roadways visible in and around the view of the cameras. The drone data captured a slightly wider cross-sectional area. The data was processed and integrated such that the most accurate, thorough TDE could be created and utilized. Accuracy considerations were considered in the collection of this data. Machined targets were placed within the HDS laser scans which were used to internally check the three-dimensional measurements; the point cloud data from the HDS laser scans was overlaid and compared to aerial maps of the area; drone data was processed and turned into three-dimensional images with the most sophisticated available software; and then that data was correlated with the HDS laser scans and the aerial images. The internal checks, the overlap, and the redundancy allowed for confirmation of the accuracy of the data. The analysis of the video also required three-dimensional measurements of the package truck. These measurements were also collected utilizing HDS laser scanners and Unmanned Aerial Vehicles* (UAVs – a.k.a. drones). The drone data captured the top of the package vehicle (not visible to the terrestrial placed scanner). The point cloud data from the HDS laser scans was integrated with the three-dimensional measurements created from the drone data. *[*The drone was deployed only after requesting and receiving FAA clearance to fly the UAV in airspace that was not restricted due to relative location to an airport or other considerations.]*

III. Processing 3D Data

In an effort to accurately recreate the movements of the bus and the pedestrian in a to-scale, three-dimensional environment, the following steps were taken to perform this engineering analysis of the surveillance video. The site inspection laser scan and drone data were processed creating an accurate, three-dimensional computer model of the intersection. The vehicle inspection laser scan and drone data were processed to create an accurate, three-dimensional model of the package vehicle. A to-scale pedestrian was also created that matched the height of the pedestrian involved in the incident.

IV. Engineering Analysis

The provided video showing the movements of the pedestrian and the package vehicle was “corrected” such that the curvature of the image due to the lens of the camera was removed and so that the video images could be used for camera-matching and tracking perspective. The frame rate of the video was approximately 30 frames per second.

Once the video images were “corrected,” a publicly available, industry-accepted computer software package was utilized to track the movements of the to-scale package vehicle and the to-scale pedestrian within the accurate, three-dimensional environment, as defined in the surveillance video. Specifically, the positions of the package vehicle and the pedestrian were tracked, frame-by-frame, such that those positions could be accurately placed within the three-dimensional computer model of the intersection. Each time a point was tracked, the software defined a level of accuracy based on the defined to-scale environment and the level of clarity of the videos. Both surveillance camera views were tracked, and the results correlated to one another.

By tracking the movements of the pedestrian and the package vehicle as seen in the videos, and then placing the movements of the pedestrian and package vehicle within the accurate, three-dimensional model of the intersection, the relative positions of the vehicle and the pedestrian can be accurately viewed from anywhere within the three-dimensional environment. Additionally, since the environment and the vehicle are to-scale, the view of the package vehicle operator, sitting within the vehicle, can be accurately simulated and defined. That is, the three-dimensional analysis allows one to "see what the package vehicle operator had the ability to see."

Since the data does not define precisely where the head/eyes of the package vehicle operator were as he turned, the engineering analysis considered a typical head placement of the vehicle operator and then evaluated what the operator could see when his head was moved a defined distance forward, rearward, to the left, and to the right from that "typical" position. These movements replicated the type of movements reasonable vehicle operators would be required to do as they execute a turn. The location of the package vehicle operator's eyes relative to the seat was defined placing a folding rule alongside the seated vehicle operator as he sat in a chair.

The data was collected in such a manner that the accuracy of the three-dimensional environment, vehicle, and pedestrian could be shown and scientifically proven (in several ways) to the trier of fact. Additionally, the process utilized to track the points from the videos into and within the three-dimensional environment also provided a level of accuracy for each plotted point. As such, the process easily passes any potential arguments presented relative to the *Daubert* standard. Specifically, the technique in question has been tested (in fact, there is software developed that is industry accepted that helps facilitate the analysis); it has been subjected to peer review and publication (and the references are available from numerous scientific/engineering-based organizations); the analysis process provides a known error rate; the analysis is based on basic scientific principles which are a foundation for its operation; and the analysis process is utilized and readily accepted within the scientific community as well as the entertainment industry (i.e. movie making).

V. Presentation of Results

The engineering analysis process provided the opportunity to capture and show the view of the package vehicle operator as he sat at the signal and as he moved through his right turn. The engineering analysis showed that had the package vehicle operator been attentive to the environment and pedestrians in his forward field of vision, he would have been able to view the pedestrian as she crossed the roadway and as she approached and moved in front of the package vehicle.

The manner in which the data was collected and how the analysis was completed allowed for a variety of presentation possibilities. This included a story-board approach where each step of the data collection process was shown; where the correlation of the field data leading to the accurate, three-dimensional environment, vehicle, and pedestrian was shown; where the manner in which the video was corrected was shown; where the tracking of the movement of the pedestrian and package vehicle within the video was shown; where the way in which that data was then transferred to the three-dimensional environment was shown; and finally, what the package vehicle operator could see was shown.

From the time this engineering-based analysis was completed on this case, technology had moved forward. New software has allowed for the same analysis to be enhanced via interactive software that allows for the smooth and accurate movement of the package vehicle operator's head. That is, using similar controls utilized by video "gamers," the torso and head of the operator can be moved around (as if the operator were leaning forward or looking around) to see what could be seen.

Now, the latest in technology allows for the trier of fact, through virtual reality glasses, to be placed within the package vehicle and within the three-dimensional environment to actually move around and see what the operator could see.