

Using Security Camera Video in Accident Reconstruction

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Abstract: In November of 2006 a family with small children was crossing the street in downtown Denver when they were hit by a DUI driver that fled the scene. A license plate that was left behind led to the arrest of the driver and passenger a few hours after the collision. There were contrasting witness statements about what happened due to the traumatic nature of the event. Several video cameras in the area captured the event. The video recordings from those cameras were used in conjunction with a scale diagram and traffic engineering report to clarify the actual sequence of events as well as determining the vehicle's speed. The author was involved in this investigation and discusses the methodology behind the speed determination as well as how he was able to determine the driver had a red light when the light was not visible in the video.

Keywords: accident investigaiton, accident reconstruction, video analysis

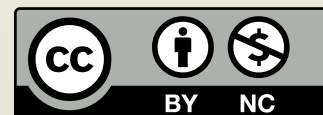
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Introduction

Events caught on video have intruded into our lives thanks to the World Wide Web and the creation of sites such as YouTube; not to mention the media's willingness to share almost anything that has been sent to them that they consider newsworthy. All types of cameras watch and record us, both intentionally and unintentionally. They are owned by private citizens, companies and even governments. According to a CBS News article written by Daniel Schorn on September 6, 2006 titled "How Chicago Authorities Keep an Eye on the City," authorities will be linking about 1000 private sector cameras with 2000 government cameras by 2016. These cameras will be monitored by a command center and used for many purposes. Events captured on video have been used to both prosecute and exonerate the "actors." The advantage of video is that,

as long as it hasn't been tampered with, it tells the truth. If this truth is interpreted correctly by investigators it is a great asset to an investigation.

Cameras can be both a blessing and a curse because many are monitored without being recorded. Under the right conditions they can be used to identify a driver, determine the speed of a vehicle, determine the condition of traffic signals, and many other facts. "Under the right conditions" being the key phrase. If the video is of poor quality then it might be of no help at all. Many times the camera is pointing in a direction that does not allow it to capture anything of value to your investigation. Cameras at many intersections only monitor the presence of vehicles to activate timing sequences and aren't recorded at all. Other users often have not learned how to properly set up their equipment and are unaware no recording is taking place.



Background

In November of 2006 a family of four was crossing a street on foot then they were hit by a full- sized pickup truck in downtown Denver, Colorado. The operator fled the scene and the unoccupied truck was located a short time later. The driver and passenger were arrested several hours later through the intensive effort of many different units within the police department. The collision claimed the life of a mother and her two small children. The father sustained serious injuries but survived.

The scene involved an entire downtown city block along with the intersections at either end. There were witnesses at the first intersection that stated the pickup approached a red light and slowed down just enough (while honking his horn) to drive around a vehicle that had stopped for the light. He ran that light and accelerated to the next intersection. Without honking his horn he ran the second red light and struck the family. There were many witnesses who remained at the scene. As is usually the case, however, they were not able to dependably recall what the condition of the traffic signal was at the time of the collision. They were also unable to identify the driver.

The job of the accident investigators in this case was to bring together all of the evidence and try to determine what happened based on that evidence. Fortunately for the investigator the entire block on one side of the street where the collision occurred was occupied by a tenant using sophisticated security systems. That tenant had surveillance cameras monitoring activity along its perimeter. These cameras captured glimpses of the entire event, although at times at the periphery of their view. This video was used to tie together all of the different elements of the collision without bias. In this case the video that was captured provided enough “glue” to join together other pieces of evidence or testimony that allowed all of the pertinent questions to be answered.

The questions in this case included:

- How fast was the pickup travelling?
- Did the pickup run the red light at the time of the collision?
- Did the pedestrians cross against the signal?

Speed

There are several methods to determine a vehicle’s speed depending on what information is available. Information typically available to an accident investigator includes: distance a vehicle travelled while accelerating/decelerating, time for a vehicle to accelerate/decelerate, speed (velocity) obtained after accelerating/decelerating, or the rate at which the vehicle accelerated/decelerated. In this case the investigators were only able to obtain time and distance information so they were left with estimating the truck’s average speed (or velocity) using a time/distance analysis. This meant that they had to know how far the vehicle travelled (in feet or meters) over a known period of time (in seconds). They could then determine how fast the vehicle was travelling in feet or meters per second. This information could then be converted into miles per hour (or kilometers per hour).

The video in this case came with its own player, or software, that allowed the viewer to see a time stamp on the screen. It also had a feature that allowed the viewer to move through the video one frame at a time. As each second advanced on the screen’s clock the number of frames between each second could be counted to determine the number of frames per second. These particular cameras used a motion sensing technology so they recorded at different rates depending on if they detected motion or not. This type of system is often used to save on storage space. This meant that the investigators had to be certain to determine the frame rate correctly at each location or the speed estimates could be significantly off by applying incorrect timing across a distance. Some reliable sources for determining the correct frame rate are the equipment man-



ufacturer or an employee of the company that provided the video who has experience with the equipment.

In this case video from four different cameras was used to follow the path of the pickup from different perspectives. The frame rate for each video was determined at specific locations of the pickup's path to provide time stamps at each of those locations. Those locations were then accurately mapped by comparing the video snapshots to a scale diagram of the block that was created using a total station and CAD software package (CAD Zone). The greatest potential for error existed when trying to estimate the vehicle's position from snapshots of the video. This was dealt with by using ranges for the distances when calculating the speed during different video segments.

Figure 1 and Figure 2 are snapshots captured from Camera 5. The position of the truck in each of the snapshots was plotted on a scale diagram. The distance between each position could then be accurately measured using tools in the software. The travel distance for this segment was estimated to be 37 feet (11.28 meters). The time it took to travel that distance was 0.5 seconds. The formula to determine an average velocity over a known distance and time is $v = \text{distance} / \text{time}$. Therefore, $v = 37 \text{ feet} / 0.5 \text{ s} = 74 \text{ fps}$. 74 fps can then be converted to 50 mph. In metric units it would be $v = 11.28 \text{ m} / 0.5 \text{ s} = 22.56 \text{ mps}$ which can be converted to 81 kph. The posted speed limit for this roadway is 25 mph, or 40 kph.

Figure 3 and Figure 4 are snapshots captured from Camera 2. The travel distance was estimated to be 36 feet (10.97 meters) and the time it took to travel that distance was 0.5 seconds, $v = 36 \text{ feet} / 0.5 \text{ s} = 72 \text{ fps}$. 72 fps can then be converted to 49 mph. In metric units it would be $v = 10.97 \text{ m} / 0.5 \text{ s} = 21.94 \text{ mps}$ which can be converted to 78 kph.

By comparing the known travel distances over known periods of time recorded by

two different cameras (focused in relatively the same area) investigators realized results that were within 1 mile per hour of each other. This analysis was completed at different locations along the truck's path with similar results. The video showed that the driver applied his brakes and also accelerated at different locations along his route.

Figure 1 (top) and Figure 2 (bottom)



The velocity estimates were, therefore, only applicable in the areas they were calculated and a note was added to the report to that effect.





▲
Figure 3 (top) and Figure 4
(bottom)

Traffic Signal Timing

Figure 5 is the diagram that was created as a potential court exhibit. It is to scale and the vehicles were plotted on the diagram based on snapshots obtained from different cameras. The vehicle's position was determined using multiple camera angles, but there wasn't enough space on the diagram to include all of the photos.

When the collision was captured on camera 78, it was at the far end of that cam-

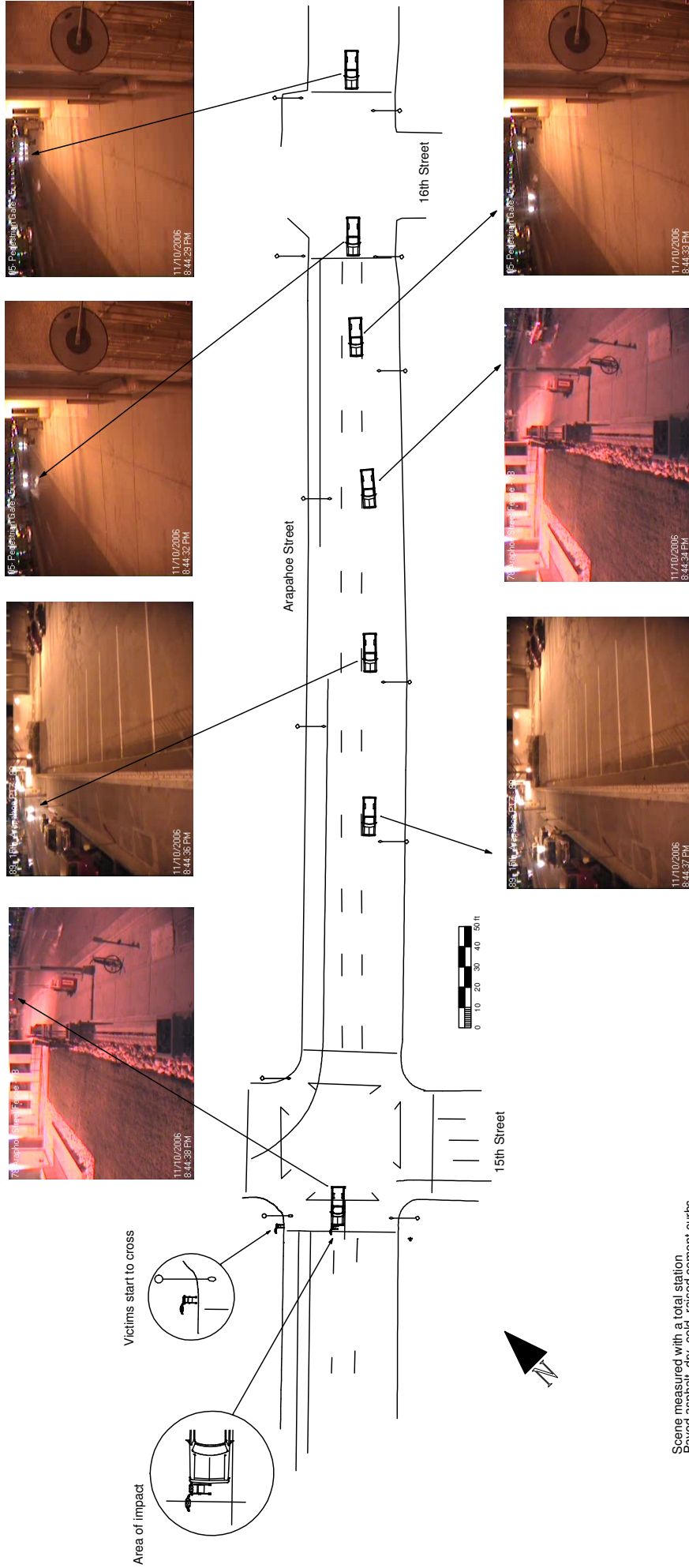
era's view. Investigators were not able to see the traffic signals or pedestrian signals at the intersection where the pedestrians were struck because they were just out of frame. Camera 5, however, captured the condition of the pedestrian signal at the first intersection. Once the pedestrian signal stops flashing the corresponding traffic signal simultaneously changes to yellow for 3 seconds followed by red for 2 seconds in all directions. This was used to prove that the pickup ran the red light after it had been red for 2 seconds based on time stamps on the video. Traffic signal timing reports were obtained from the City's Traffic Engineering Department to verify this information. Their report also documented that the signals at both involved intersections were coordinated as part of a downtown signal timing plan, and that no fault codes were recorded at either location on the day of the collision.

Both intersections are timed so that the traffic signals turn red in all approach directions within one second of each other. This allowed investigators to determine that at the same time the pickup ran the red light at the first intersection, the pedestrians received the "Walk" signal to start crossing the second intersection. The distance between the pickup and the family at this time was approximately 560 feet (170 meters), or one fairly large downtown city block. Approximately 9 to 9.5 seconds later the family was hit by the pickup while in the center of the crosswalk, having made it only halfway across the street. This fact could not have been proven without the video in this case.

Discussion

The investigation ultimately revealed that both the driver and his passenger were very intoxicated at the time of the collision. They both gave statements indicating that they made an attempt to hide the vehicle





Scene measured with a total station
 Paved asphalt, dry, cold, raised cement curbs
 Times indicated are based on the Federal Reserve cameras
 Traffic signals for Arapahoe at 16th and 15th where red at 27 seconds
 An "All Walk" pedestrian signal at 15th began at 29 seconds

◀ Figure 5

in a garage but were unsuccessful. They fled in a different vehicle, split up, and were eventually arrested. The driver pled guilty to 3 counts of vehicular homicide, 2 counts of child abuse resulting in death, DUI, hit and run, and vehicular assault. He was sentenced to prison for many years. The passenger pled guilty for his role as an accomplice and initially received probation as a condition for his truthful testimony. The terms of his probation were violated within a short time, so he went off to prison as well.

Video in this case truly was the glue that held all of the pieces of evidence together. It also allowed the investigators to answer important questions without having to rely solely on witness accounts. If a picture is worth a thousand words, then video can certainly be worth a million.

Great care must be taken when trying to use video to determine the speed of an object. The frames per second must be determined and then verified through a second source, if possible. If the speed can be determined from two different perspectives (or methods), then that is also desirable. When copying the video from one format (or program) to another the software often compresses the video. When this occurs the frame rate might change, which could complicate an analysis if you are not aware that this occurred. As with any other digital evidence it is recommended that the original video source is secured in a safe place and that a working copy is used to complete the investigator's analysis.

After making use of the video in this investigation the author has had the opportunity to use it on other occasions. One of the city's cameras captured a collision between two vehicles in the very corner of the video frame. Approximately 2 minutes later the camera operator became aware of the collision and moved the camera to view the

unfolding events. Once the camera's view widened it captured a pedestrian signal changing from "walk" to "don't walk". The signal timing of the intersection was then used to reverse extrapolate the condition of the signals at the time of the collision to determine which vehicle ran the red light. Investigators now carefully examine their scenes for the presence of video cameras. Even if the video only helps to answer one of the questions investigators have, that might be the answer that breaks the case wide open.

