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A Case Study: Reconstruction of Municipal Bus Accidents

Reconstruction of Municipal Bus Accidents

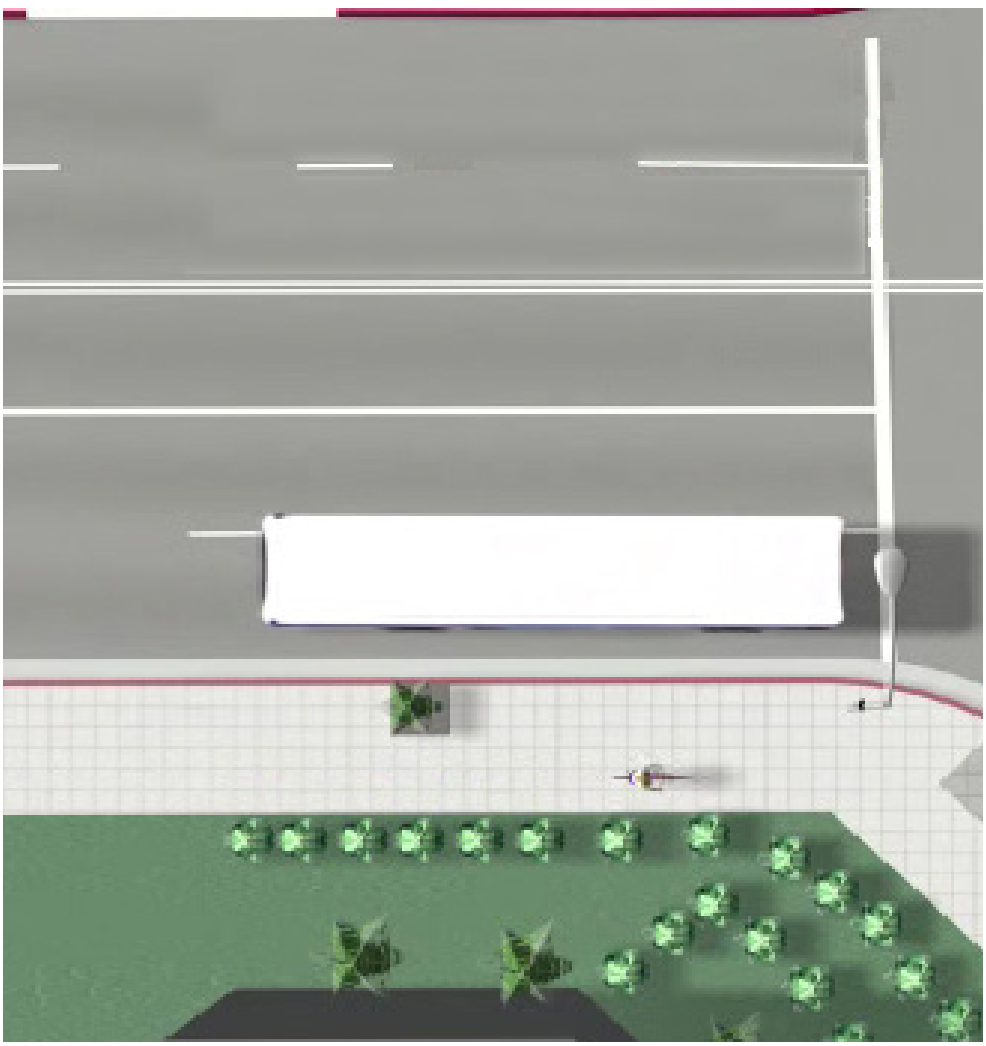
Using 3D Computer Simulations and Analytical Techniques to accurately reconstruct and illustrate an event.

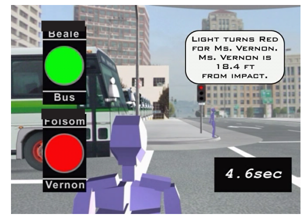
The Challenge

How to develop an accurate reconstruction of municipal bus accidents when there are no skidmarks and little physical evidence.

Solution

The lack of skidmarks and other physical evidence present challenges when determining point of impact, speed and acceleration. Fortunately, many of today's buses are equipped with security cameras that record the passing of items outside the bus. These recorded videos can be used as the foundational basis for determining the factors needed to reconstruct the accident properly.





Lack of Physical Evidence

Accidents involving municipal buses often involve pedestrians or cyclists, and can be difficult to reconstruct due to the lack of physical evidence. Often there are no skidmarks, dents or scratches, which are needed to determine the velocity, acceleration, point of impact and trajectories of the involved parties. The large size of the bus, including over-sized mirrors, widow pillars and other internal sight obstructions presents unique visibility challenges.

Fortunately many municipal buses are now equipped with security video cameras. While the primary purpose of these cameras is to record events inside the bus, the cameras also record what is passing by outside the bus windows. PSI has developed several techniques that can be used to create an accurate reconstruction of what occurred outside the bus, using the captured video from these cameras.

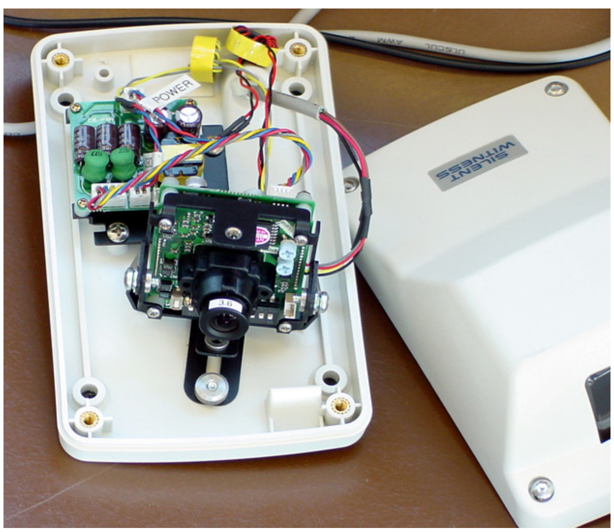


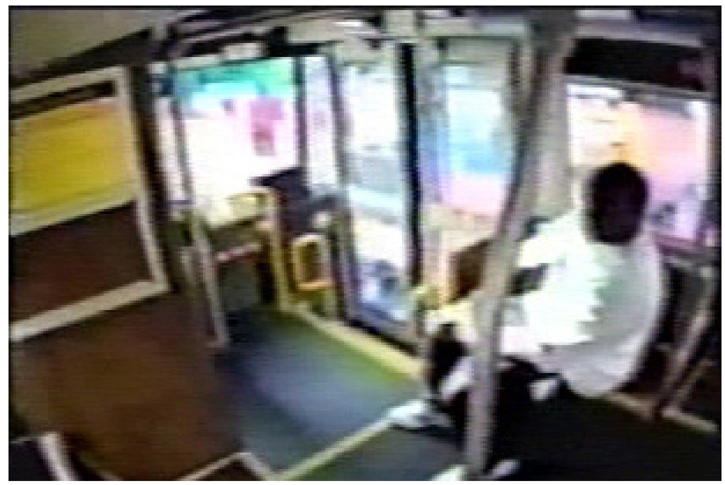
Photo of Surveilance Camera with Cover

Screen Shot of Surveilance Camera Images

Video Processing Overview

First the video from the security cameras is separated into individual frames or pictures, which are enhanced digitally to improve clarity and picture quality. These still frames each depict the bus interior and exterior at a single point in time. The rate at which the cameras record the video must be determined in order to use the sequence of frames as a timer. The recording rate, or refresh rate, determines the smallest time interval that can be analyzed for the reconstruction. Typically, today's security cameras record at a rate of 1.5Hz or 1 new picture every 2/3 of a second. Therefore, objects that pass by the bus and are visible in the video 2 frames apart occurred 2/3 x 2 = 1.33 seconds apart. This method can be used to determine the time between any event or object that is recorded by the video, such as the passing of trees or traffic signals.

Video camera screenshot Time Segment #1



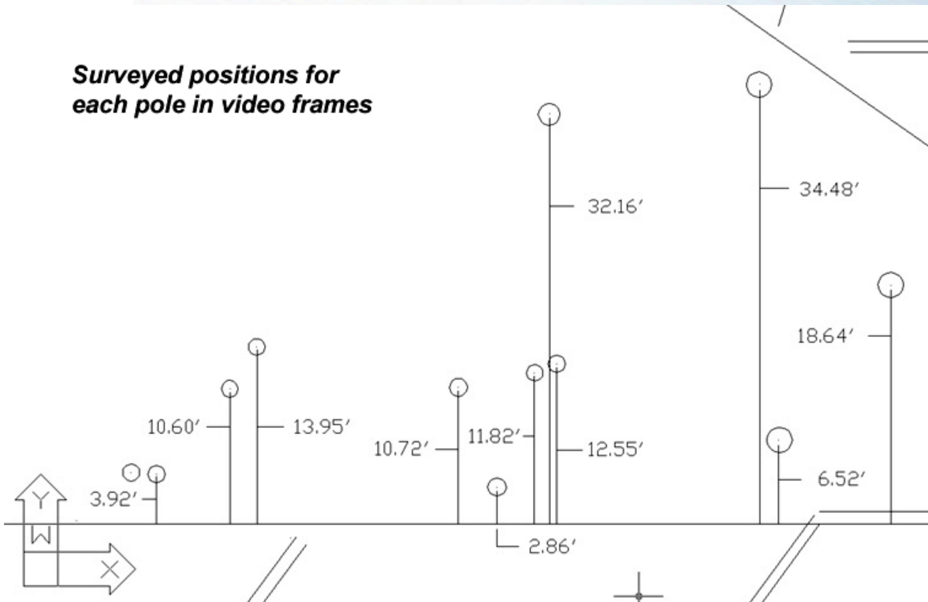
Video camera screenshot Time Segment #2

Video camera screenshot Time Segment #3

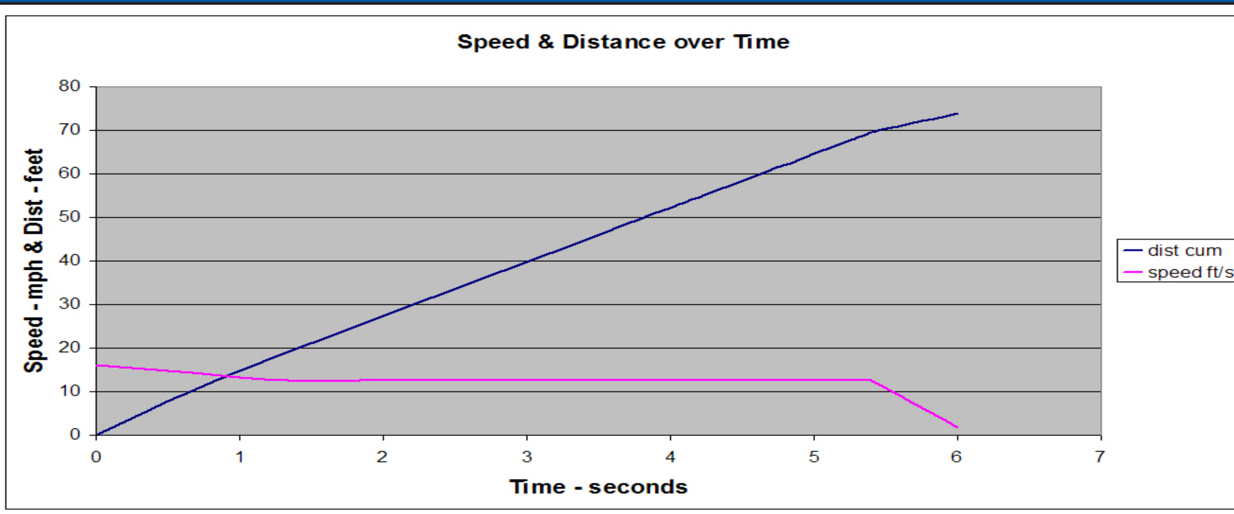
Scene Measurements

After the individual pictures are digitized and enhanced and the recording rate is determined, the scene outside the bus during the critical time period is surveyed using a Total Station or 3D Scanning Laser. The data collected is used to create either a 2D or 3D Working Model of the scene, providing distances between objects seen passing by the bus in the security camera video.

Coupling Distances with Elapsed Times



Coupling these distances with the elapsed times determined in the previous step, it is now possible to calculate velocity and acceleration of the bus in the period prior to impact.



The working model can then be used as the basis for a compelling 3D animation of the event and illustrate what was available to be seen by the bus driver immediately prior to impact.

The Scenario

The following example from a recent case illustrates how an accident can be reconstructed accurately and with proper foundation using the video from the onboard security camera.

A Los Angeles city bus collides with a bicycle rider while making a right turn in an intersection. The bike rider is crushed under the bus and suffers major injuries. The plaintiff's attorney looked to PSI to help reconstruct the motion of the bus and create an animation of the incident. The defense alleges that the bike hit the bus and that the bus was acting in accordance with traffic rules. An accurate reconstruction is needed to determine who is at fault.

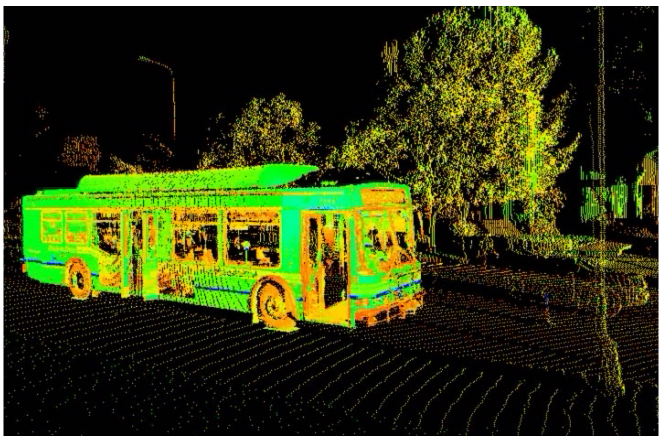
Scene from animation: Bicycle colliding into bus.

Typical City Bus.

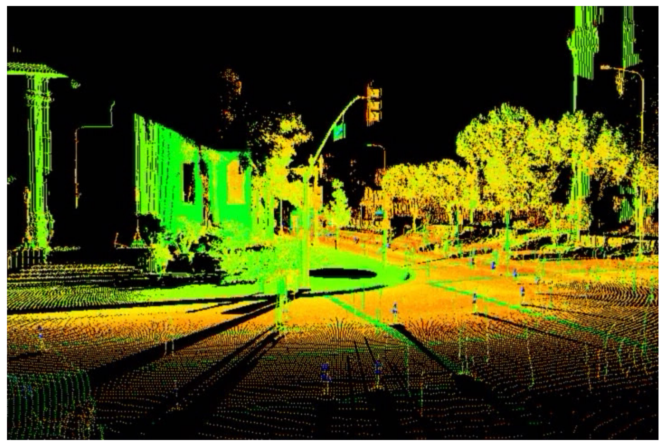
3D Laser Scanner

A 3D laser scanner is an advanced class of survey instruments that is used to remotely measure surface geometry of sites and structures with extraordinary completeness, accuracy and speed.

Unlike traditional surveying tools that are used to record certain, selected points within a scene, a 3D laser scanner automatically blankets the scene with millions of closely spaced point measurements. The resulting "point cloud" is used to create extremely accurate 3D Models of everything that the laser "sees". No other method of scene or object data capture comes close to the level of accuracy demonstrated by the laser.



Laser scan of bus.



Laser scan of scene.

Laser-Assisted Photogrammetry

The velocities and trajectories of both the bicycle and bus must be synchronized in order to reconstruct the accident. The video camera located onboard the bus had taken several pictures of stationary objects located on the sidewalk.

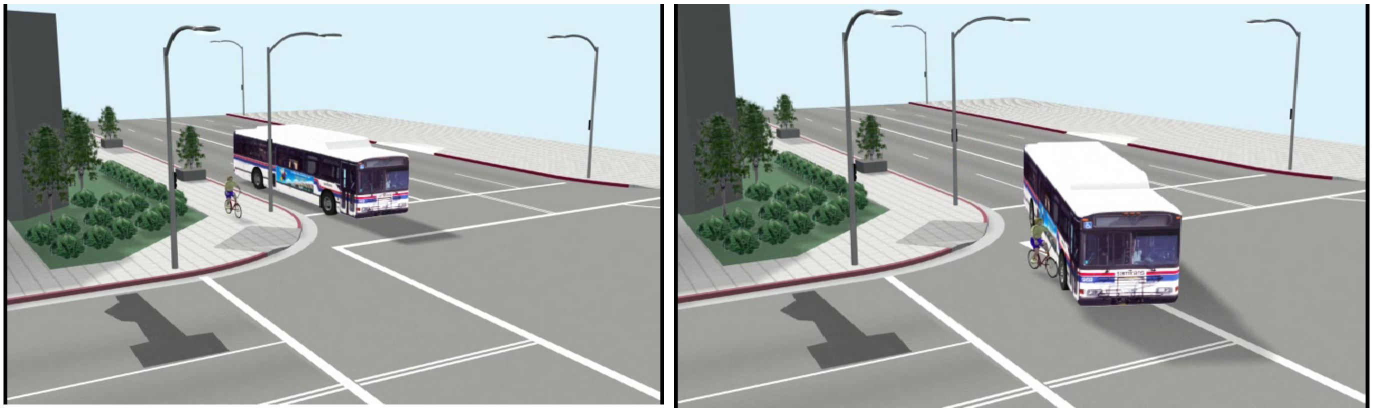
Using the 3D scanning laser, the entire area was laser scanned and recreated "virtually" in the 3D Working Model. The Working Model provided the exact location of the objects filmed by the onboard video cameras and photogrammetry techniques were then used to determine velocity and acceleration at impact of the bus. Reconstruction parameters were derived for the bicycle by the expert.

As is often the case, the camera did not film the actual impact. However, since velocity and trajectory of the bus were determined for three seconds prior to impact via analysis of the video, the point of impact could be derived.

The derived motion parameters for bicycle and bus were imported into the 3D Working Model and used by the expert to determine that the bus did not stop in the intersection before turning into the crosswalk, as was required by law and testified to by the bus driver. The working model demonstrated that had the bus stopped at the intersection before it made the turn, the accident would have been avoided.

Animation Analysis

The results of the analysis are illustrated graphically in a real-time computer animation, depicting the motions of the bus and bicycle up to and including impact.

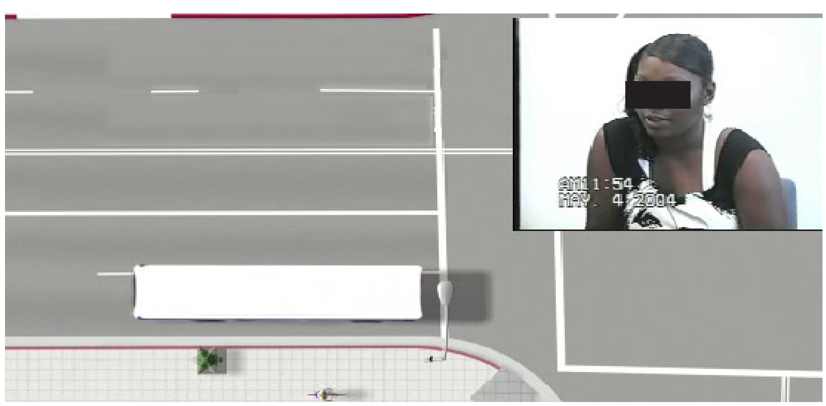


In this case, the attorneys used videotaped depositions to record the testimony of the bus driver as she recounted her actions leading up to the accident. In her testimony, the bus driver claimed that she had in fact stopped at the intersection prior to passing through it and had properly looked in both mirrors and cleared the way prior to entering the intersection.

Split-Screen Impeachment

From the laser-based analyses performed with the onboard video camera, it is apparent that she did not act as she testified. This discrepancy between her testimony and the facts of the case was exploited and highlighted using a split screen to show the animation. In one side of the screen, the video of the bus driver testifying to her actions was displayed. As she recounted her action step by step, the second screen showed the results of the analysis and highlighted each discrepancy between her recorded testimony and the facts as determined by the Working Model.

Conclusion



The effect was a very powerful and compelling impeachment of the bus driver, effectively rendering her testimony as false. The case settled in favor of the plaintiff.