Using Motion Layers to Analyze Pre-Accident Event Timelines

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ABSTRACT

This paper presents a technique for using HVE's Playback Editor to analyze automobile accidents where one of two conditions exists. The first is when an analysis of the pre-accident timing or visibility is necessary. For example, a vehicle may momentarily hinder visibility as it passes between two others that then collide. The second is when the boundaries of two vehicles overlap during some portion of the event, but do not come in contact. For example, a car may pass beneath some portion of a semi-trailer without making contact. The technique involves superimposing two vehicles in the same scene and manipulating their positions relative to each other by changing a time delay.

INTRODUCTION

HVE's Playback Editor allows separate events to be played together in a single window, thereby generating a seamless 3D representation of an entire composite event. The most common usage of this functionality is to assemble motion from different computation models in a single scene. However, there are ways to use the Playback Editor for event analysis as well. The Playback Editor can be used for analyzing the timing of events where no impact is involved, and for placing vehicles in visually overlapping positions without contact. This paper will demonstrate situations where these techniques have proven useful, and describe a method for achieving the results.

EVENT TIMING ANALYSIS

The Playback Editor's functionality can be used for determining the timing of events before impact when some vehicles or inanimate objects (such as signs) were present but not involved in the accident. Once the scene is built, and separate events leading up to the accident are completed, timing can be manipulated in the Playback Editor to analyze the positions of objects relative to each other.

The first example is from an accident between a bicyclist and a tractor-trailer rig at a rural road intersection with a highway. There was coherent testimony from a witness and the driver of the rig, plus physical evidence. Figure 1 shows the scene and the path of each vehicle through the intersection.

The motions of the truck, the witness vehicle, and the bicycle could be combined in a single event. However, using this method requires multiple iterations of changing speeds/positions and recomputing results. Also, the relative positioning of vehicles at the crucial time (perception) cannot be observed immediately after making changes. This means time-consuming work for the user.

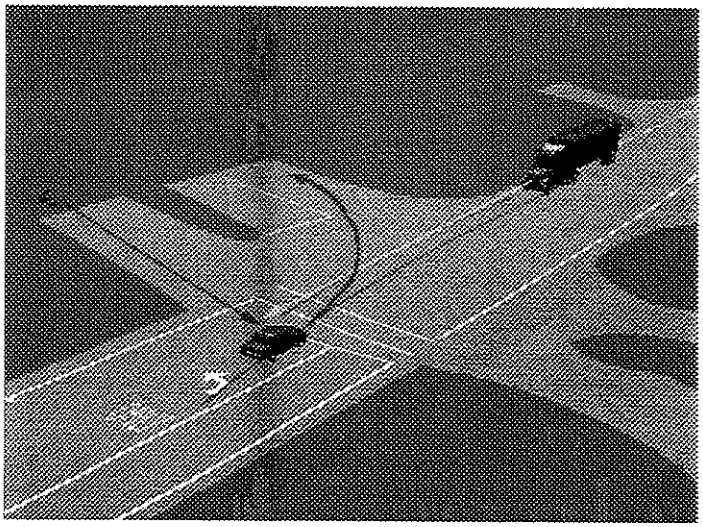

Figure 1. Vehicle paths

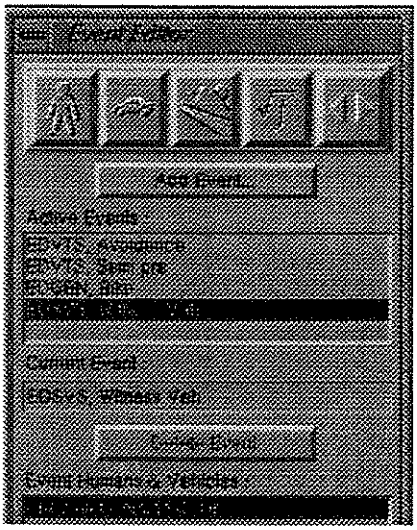

Figure 2. Individual events

Instead, a separate event is defined for each vehicle, taking advantage of the fact that these events are simple to define by themselves. Figure 2 shows a view of the Event Editor.

The truck's motion is defined by its skidmarks and the driver's testimony. The car's motion is modeled from the witness' testimony. She says that she started to make a left turn in front of the semi, then had to accelerate quickly because it was closer than she originally thought. The bicycle's motion is modeled using the point of impact and the slope of the ground, plus testimony that it was coasting very slowly before impact. Once these events have been set up and run, the user can turn to the Playback Editor.

As shown in Figure 3, the first step in setting up the timing analysis is to add Trajectory Simulation and Variable Output preview windows for each event. See Section 7 of the HVE Operations Manual for a detailed description of this process.

The second step is to add a Playback Window for combining all of the Trajectory Simulations and setting the camera's point of view, as shown in Figure 4. This is where the event timing analysis will occur.

The third step is to set the camera location using the numeric fields in the Camera Setup dialog. The camera is positioned relative to the semi's CG to show events from the driver's view, as shown in Figure 5.

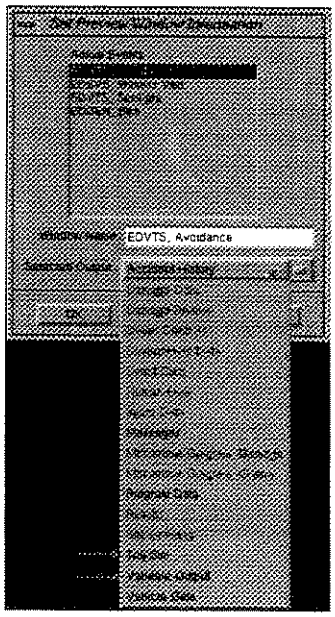

Figure 3. Previews required

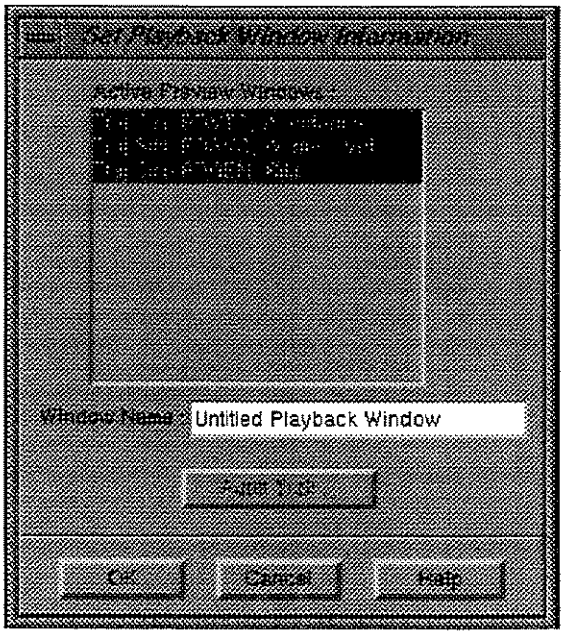

Figure 4. Playback Window Information

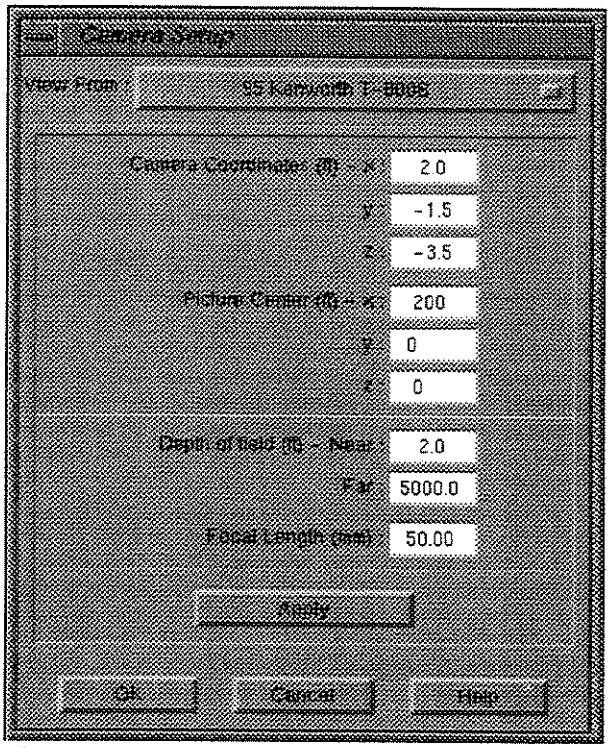

Figure 5. Camera setup for truck view

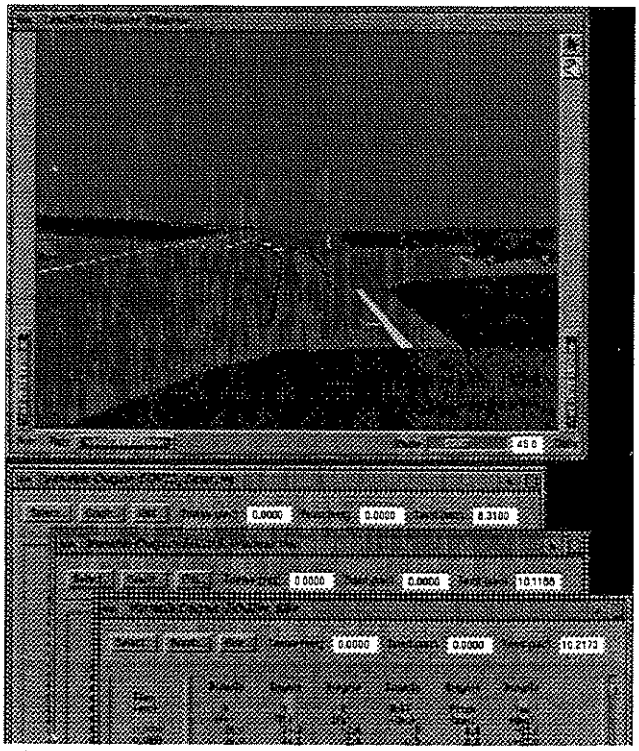

Figure 6. No delay

It is important to use the numeric fields in this dialog instead of the thumbwheels on the Playback Window itself. The Playback Window camera will reset to the position specified here whenever any event's time delay is updated. Any manipulations of the camera view via the thumbwheels will be forgotten and need to be done over each time.

The fourth step is to line up all of the windows so they can be seen easily, as shown in Figure 6. The setup is now complete and timing analysis can begin. For purposes of this exercise, timing of the witness vehicle and the bicycle will be manipulated. The semi's timing will be left alone.

A goal of the timing analysis process is to find some combination of events which accounts for the testimony of witnesses and the physical evidence observed. The driver of the car indicated she started to accelerate quickly when the semi "felt" too close. The car driver also indicated that the bicycle was near the corner of the fence when she initiated her left turn.

These statements help to establish the relative positioning between the car and the semi and the car and the bicycle. It was determined that the car provided a view obstruction between the semi and the bicycle.

With the timing unmodified, the vehicles' relative positions appear as shown in Figure 6. This is frame 200, 6.6667 seconds into the simulation of the truck's motion. From braking analysis, it was determined that the truck driver could react and stop in the distance left to the point of impact. However, the car has already passed in front of the bicycle. This means that the time delay for the bicycle and/or the car must be modified to better match the evidence.

An event's time delay is modified by clicking in the Tdelay (sec) edit box in its Variable Output window. As shown in Figure 7, the time delay for the bicycle is changed to 3 seconds. The resultant positioning of the vehicles indeed blocks the truck driver's view of the bicycle, but now the timing is such that the truck can pass through the intersection before the bicycle will coast to the point of impact.

Ideal positioning is achieved by setting the bicycle's delay to zero and delaying the witness vehicle by 0.9 seconds, shown in Figure 8. This combination blocks the truck driver's view of the bicycle at the crucial moment of perception.

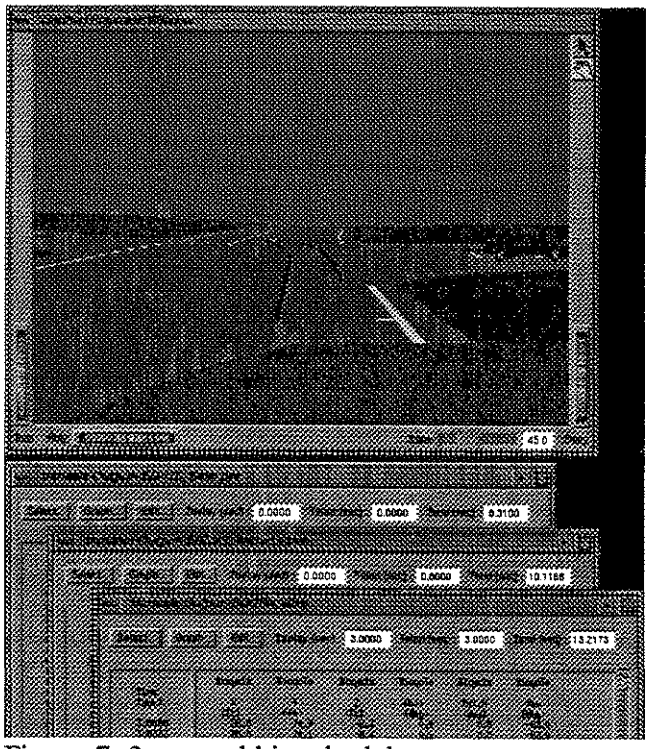

Figure 7. 3-second bicycle delay

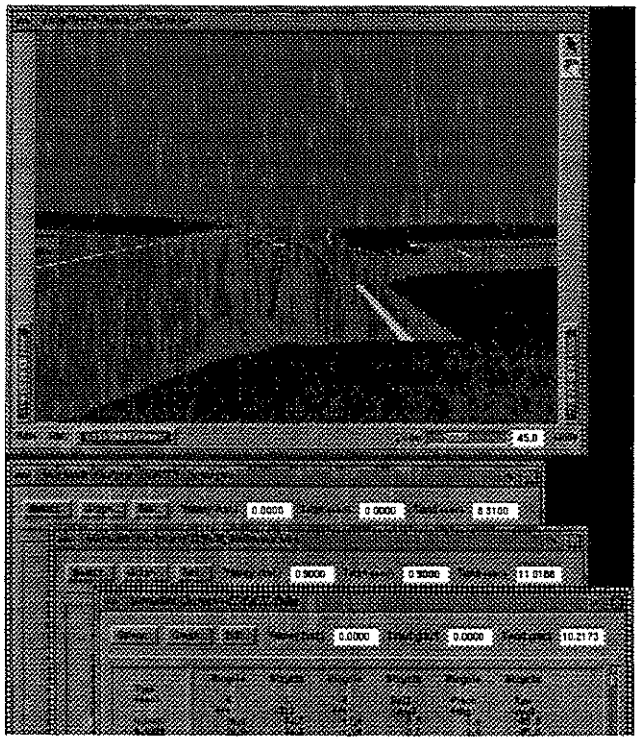

Figure 8. 0.9-second car delay

When combined with other elements in the scene as shown in Figure 9, the overall effect is that the truck driver's view of the bicycle is partially blocked for approximately one second – reducing available perception time.

This method provides a quick way to analyze several events while avoiding the need to manipulate positions and speeds of the vehicles.

OVERLAPPING

The second analysis technique using the Playback Editor concerns the ability to overlap two vehicles in the same space. For example, some accidents between tractor-trailer rigs and automobiles involve the car passing beneath some portion of the trailer without contact. Figure 10 is a stylized example showing a Hollywood-type stunt with a car driving underneath a moving trailer. Usir EDSMAC4, scenarios such as this cannot be modeled using one event because, even though there appears to be space under the trailer, a collision would still be computed due to the two-dimensional nature of EDSMAC4's collision algorithm.

The following example describes using the Playback Editor to effectively show overlapping before impact. The accident occurred between an Oldsmobile Aurora and a side-dump trailer pulled by a Kenworth tractor.

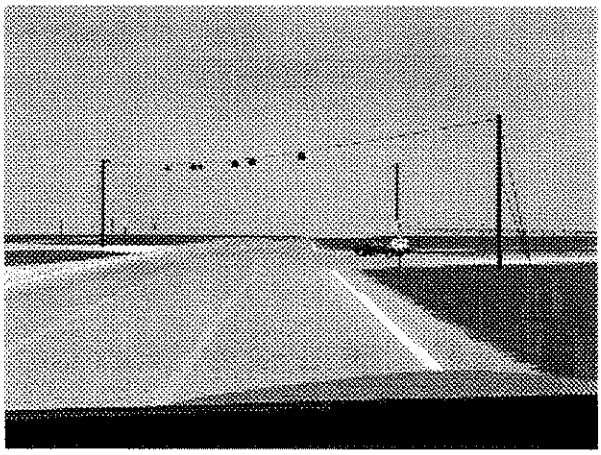

Figure 9. Textured animation with scenery

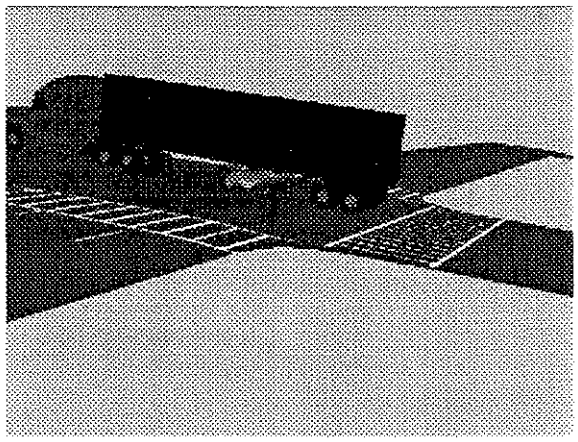

Figure 10. Hollywood stunt

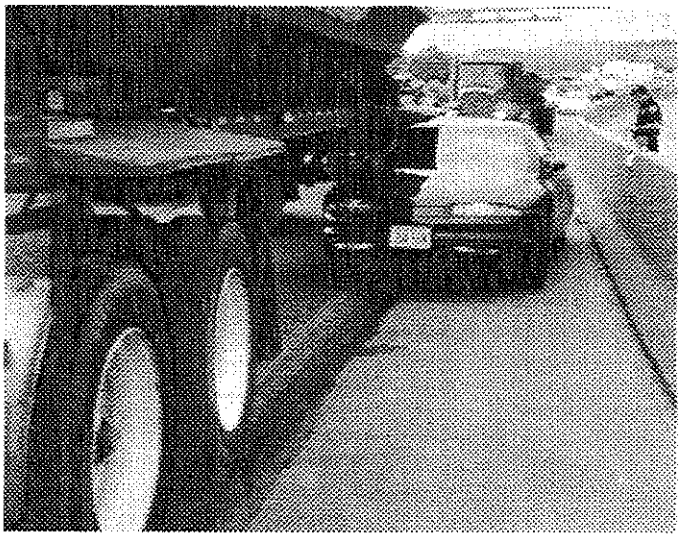

Figure 11. Trailer overlapping car

Figure 11 shows a photograph of the right-rear corner of the car pinned by the left-rear tires of the trailer. Before impact, there was a period of time when the vehicles overlapped but did not touch. The accident sequence was as follows. The driver of the semi signaled to move from the middle lane to the left lane. After seeing this signal, the driver of the Aurora attempted to pass the semi at a high rate of speed; as the car approached the rear wheels of the dump trailer, the rig continued to move left. At this point, the driver of the Aurora panicked and applied heavy braking. The car's inertia carried it forward past the trailer wheels until its speed dropped below that of the trailer, whereupon the trailer wheels contacted the rear of the car. The challenge in reconstructing this accident with HVE was showing the two in motion together before impact without generating any contact forces.

Figures 11 and 12 show the vehicles in the Playback Editor just before impact. The reader will notice an odd-looking configuration of the trailer's rear wheels. This side-dump trailer has the rear pivot centered on the rear truck, offsetting the wheels.

The skidmarks and gouge marks at the point of impact provide a point in time when the vehicles' positions are known. Working backwards, rough starting positions for the tractor/trailer and the Aurora can be established.

To analyze the accident, individual events for the tractor/trailer and Aurora are created to drive the vehicles to the point of impact. As in the previous example, this can be done without regard to their relative positioning and is therefore a very simple process.

Again, the Playback Editor is used to analyze these events to achieve a combination where the two arrive at the point of impact at the same time. For each vehicle, the time delay is manipulated using the method described above until both vehicles arrive at the point of impact at the same time.

Beyond impact, motion for the joined vehicles can be computed from the tractor/trailer's motion alone. This is due to the fact that the vehicles did not change position relative to each other after impact. Figure 13 shows the rest positions of the vehicles in the final textured animation.

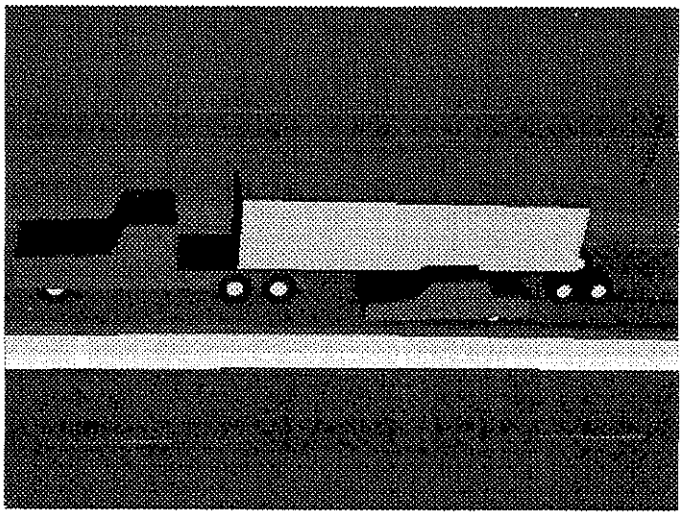

Figure 11. Side view of pre-impact

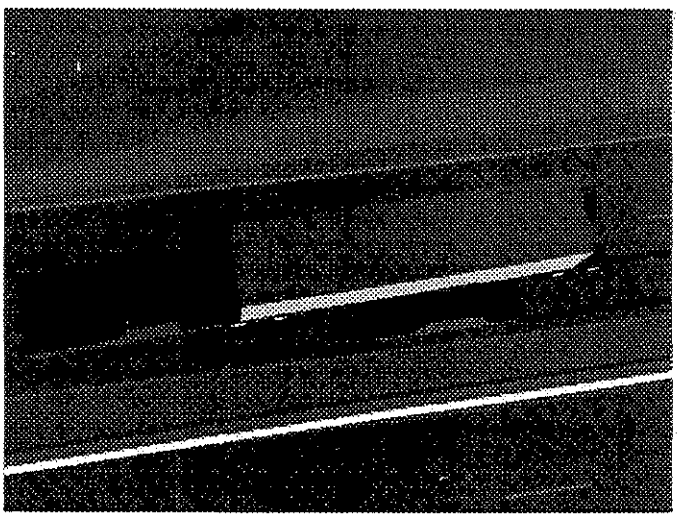

Figure 12. Top view of pre-impact

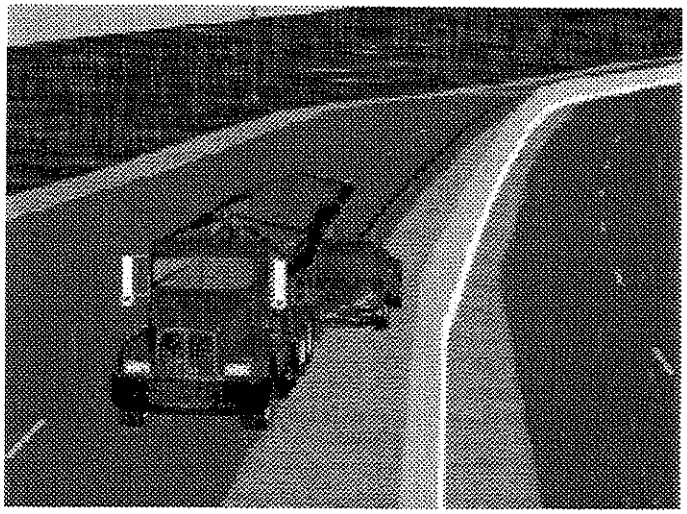

Figure 13. Rest positions from animation.

Again, this method of analysis has provided a means of achieving results that would be difficult or impossible to achieve using more commonplace methods. Used appropriately, it is a valid and time-saving technique.

CONCLUSION

This paper has presented a method for analyzing accident events using HVE's Playback Editor. The first example demonstrated event timing analysis for vehicles that do not impact each other, including a method for achieving the results. This technique compares favorably to more commonplace techniques for achieving the same results.

The second example demonstrated how the method could be used in situations where vehicles overlap without contact. This currently cannot be achieved in a single HVE event.

REFERENCES

1. HVE Operations Manual, Version 2, Engineering Dynamics Corporation, July 1999.