Processing SHRP2 Time Series Data to Facilitate Analysis of Relationships between Speed and Roadway Characteristics

Jayson Stibbe,
Graduate Assistant—Research
Texas A&M Transportation Institute

Marcus A. Brewer, P.E., PMP,
Research Engineer
Texas A&M Transportation Institute

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San Diego State University
Texas A&M Transportation Institute
Virginia Tech Transportation Institute

Introduction

The Strategic Highway Research Program 2 Naturalistic Driving Study (SHRP2 NDS) dataset is a source of "big data" that provides researchers with opportunities to analyze more than just crashes and near crashes. During an ongoing project using the SHRP2 naturalistic data, the researchers encountered and solved unique problems that arose due to either the data-collection method or the sheer volume of data. One such problem was **the task of locating a vehicle at a specific distance along a ramp, where a 50-foot error could be the difference between being in the middle of a sharp-radius curve and being stopped at an intersection**. The researchers explored various ways of processing the time series data, and found that **it was possible to locate vehicles using measurements obtained from aerial imagery.**

Methods

Researchers obtained a robust SHRP2 NDS dataset, containing more than 10,000 trips of data on 100 ramps in the 6 participating states. The dataset included time series variables every tenth of a second, as follows:

System Time Stamp (Counts up from 1 each tenth of a second)
GPS Speed (km/h)
Network Speed (km/h)
Acceleration X-axis, Y-axis, and Z-axis (g)
Gyro X-axis/Roll Rate (degrees per second)
Gyro Y-axis/Pitch Rate (degrees per second)
Gyro Z-axis/Yaw Rate (degrees per second)
Lane width (cm)
Left Lane Marker Probability (1 to 1024)
Right Lane Marker Probability (1 to 1024)
Brake Pedal Position (0/1)
Gas Pedal Position (0 to 100)
Steering Wheel Position (-720 to 720 degrees)

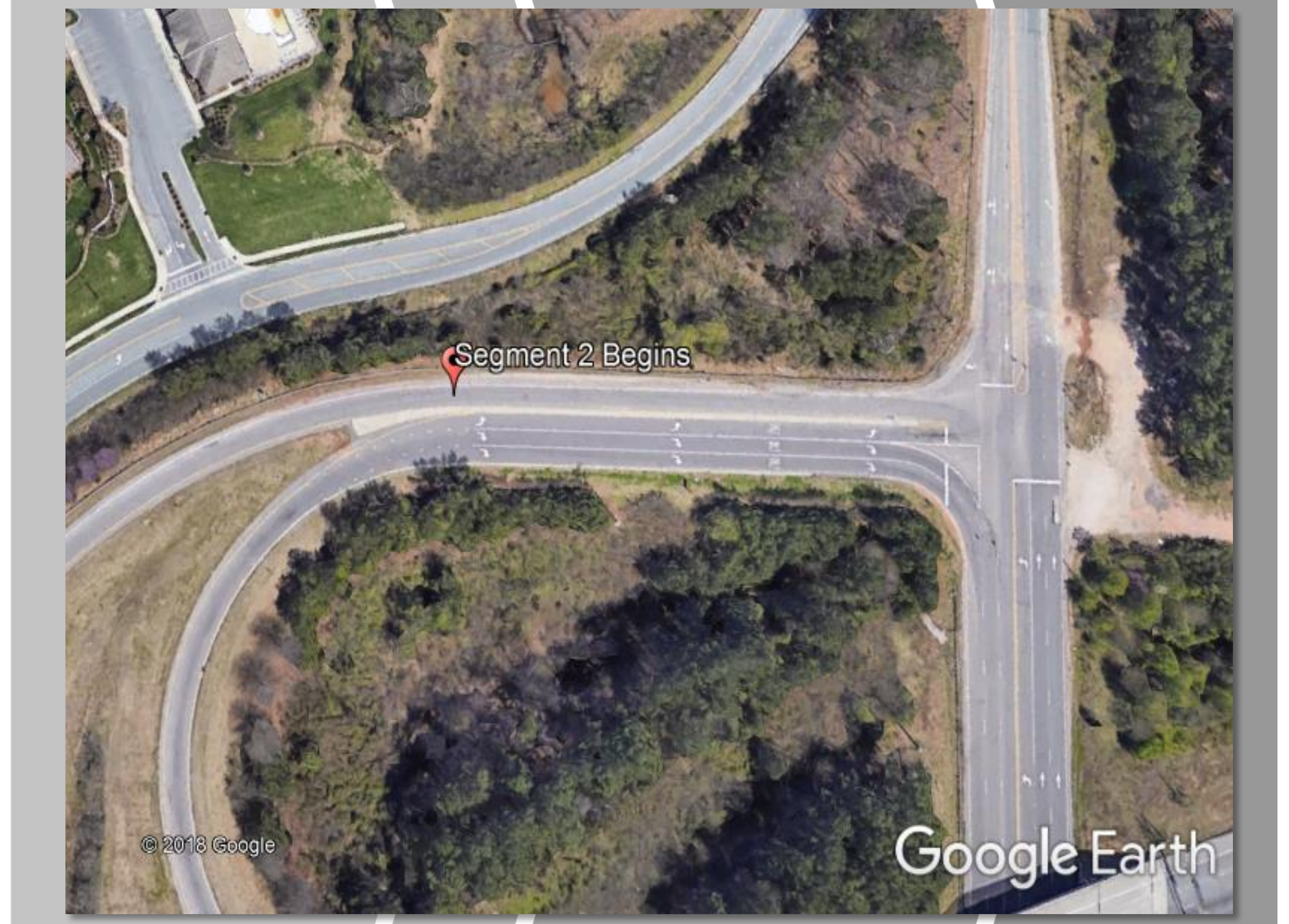
SHRP2 NDS time series variables available to the researchers in this study

This data did not identify the location of the vehicle on the ramp and did not contain information on the ramp geometrics. The researchers collected supplementary ramp data from Google Earth.

Results

To be able to compare the ramp geometrics to the vehicle dynamics on the ramp, the researchers needed to be confident in the location of the vehicle at each data point, and so looked for ways to do this. They determined the best bet was to find variables in the time series data that shows transitions from tangent segments to curves and vice versa. The "yaw rate" variable could be used for this purpose.

$$Yaw\ Rate = \frac{degrees}{second}$$



Freeway ramp segment change to identify with the time series data

With yaw rate, it is possible to find the distance required to travel one degree around a circle's circumference. This value can be directly compared with the radius of the curve as measured from Google Earth. The process for locating vehicles is as follows:

1. Find the incremental distance traveled for each line of data (ft per 0.1 sec).
2. Calculate how far the vehicle has traveled around the circumference for each line of data (deg per 0.1 sec).
3. Divide these to find the number of feet per degree on the circumference of the circle the driver is driving and compare this with the number of feet per degree on the measured curve.
4. Establish a "turning threshold" to determine when the driver transitions from a curve to a tangent and vice versa.
5. Compare the inferred distance of the curved segment with the measured distance. If the distances are not within 5 percent, adjust the turning threshold.

Incremental Distance (ft)	Absolute Angle Change (deg)	ft/deg Moving Average	Segment 1	Segment 2 ft/deg	Turning Threshold	Transition Point
5.29	0.115	42.8	Tangent	8.4	3.0	0
5.29	0.106	42.0	Tangent	8.4	3.0	0
5.29	0.127	40.5	Tangent	8.4	3.0	0
5.29	0.124	38.7	Tangent	8.4	3.0	0
5.29	0.139	36.6	Tangent	8.4	3.0	0
5.29	0.136	34.4	Tangent	8.4	3.0	0
5.30	0.166	31.9	Tangent	8.4	3.0	0
5.32	0.204	29.0	Tangent	8.4	3.0	0
5.34	0.231	16.6	Tangent	8.4	3.0	Segment 2 begins
5.36	0.257	24.1	Tangent	8.4	3.0	0
5.38	0.275	21.8	Tangent	8.4	3.0	0
5.38	0.287	19.3	Tangent	8.4	3.0	0
5.38	0.316	17.5	Tangent	8.4	3.0	0

Applying the process to find the beginning of the curve segment.

Conclusions

- The SHRP2 NDS Dataset is powerful but comes with unique challenges that must be addressed.
- When using SHRP 2 NDS data, it is often necessary to supplement time series data with other data sources.
- As shown in this paper, **if the radius of the curve is known, it is possible to roughly locate a vehicle on a ramp with only speed and yaw rate data.** The smaller the radius, the easier the process and the more precise the location.

Future Research

- Research that could **verify and refine this process** would be useful. For this to work, the actual position of the vehicle would have to be known for comparison.
- **Naturalistic time series data could potentially be used to find other variables, such as superelevation**. Research that could verify these processes would be valuable.