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ENEL 862

Vehicle Movement Analysis Report

Project Description

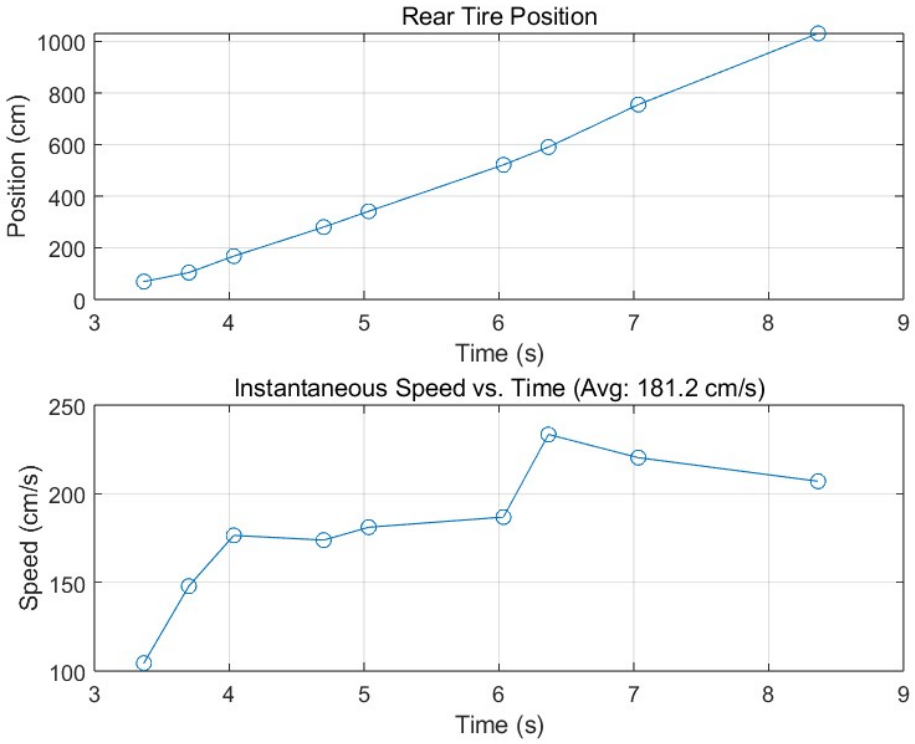
This project is to extract information from the videos about the CR-V moving across the parking lot over a speed bump. This report analyzes the vertical and horizontal motion of a CR-V as it travels over a speed bump. Using video analysis techniques in MATLAB, the vehicle's speed, wheel displacement, and body movement were estimated.

Results and Explanation

a) Based on the number of pixels the vehicle covers how many cm is each pixel.
Pixel distance between front light and rear tire ≈ 368.15 pixel
Real-world vehicle length (incl. half tire) = (177.6 + 8.1/2) * 2.54 ≈ 461.39 cm
Pixel-to-cm ratio = $\frac{461.39}{368.15}$ ≈ 1.25 cm/pixel
To calculate how many cm per pixel, we need to get the pixel length and real length of the CR-V. As there are many trees in the background, I cropped the selected frame to minimize distractions when detect the vehicle body length. It is easier to detect the front light and the tire on the back of the car, so I applied the Hough Transform to detect the circles representing the light and tire.

The center point of each circle is used to determine the length of the car, with the assumption that the center point of the tire circle is located at half the width of the tire. Finally, I converted the total length to centimeters and divided it by the number of pixels to calculate the pixels-to-centimeters ratio.

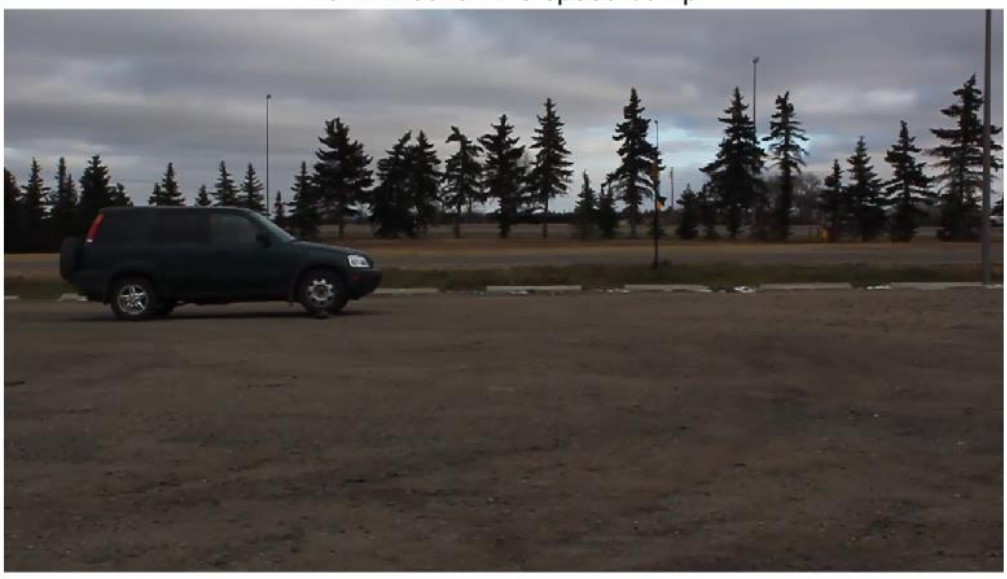
b) What is the speed of the vehicle average and instantaneous? Provide a graph of the instantaneous velocity in time.
Average speed ≈ 181.2 cm/s
Instantaneous speed: Varies over time; see graph below.



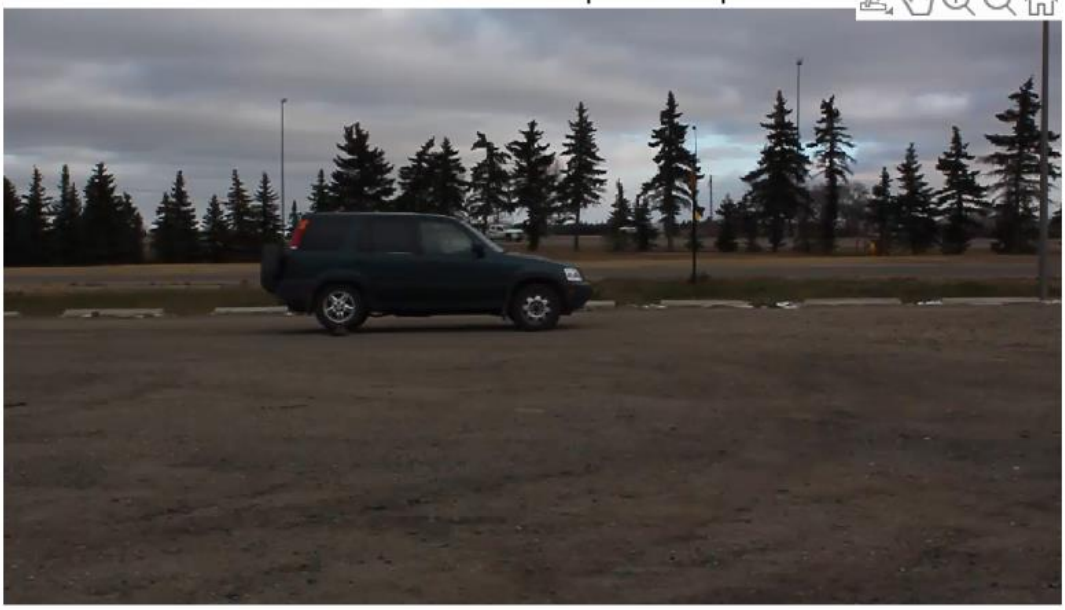
To calculate the speed of the vehicle, we need to track its position as it moves across the parking lot. The rear tire is easier to detect over time. The top graph illustrates the position of the detected tire over time, while the bottom graph represents the instantaneous speed at each detected time point. By calculating the mean of the instantaneous speeds, we can obtain the average speed of the vehicle over time.

c) Find the wheels of the CR-V as it goes over the speed bump and present representative images

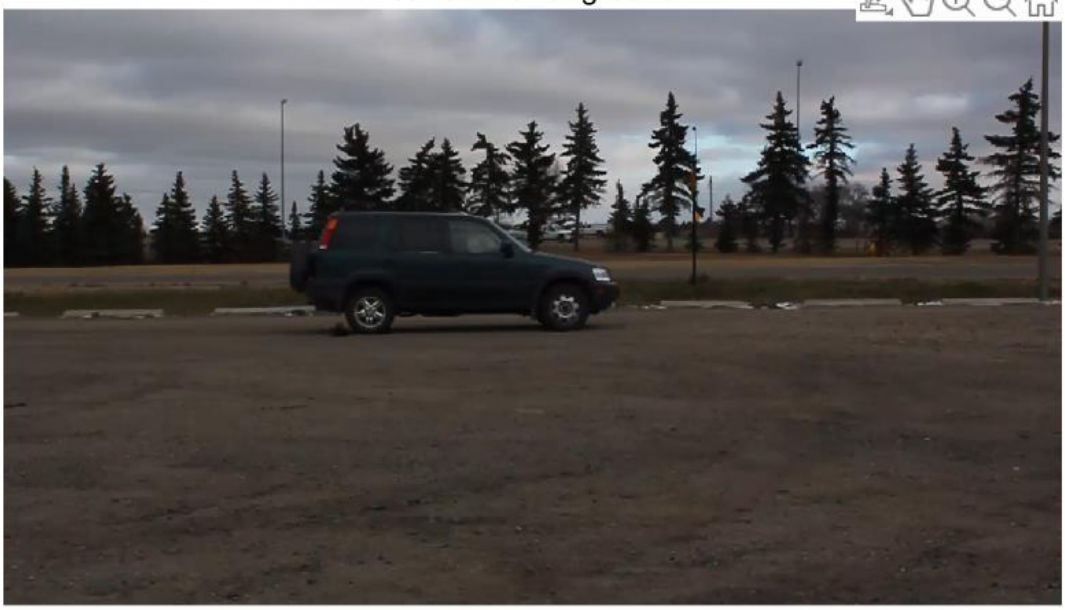
front wheel on the speed bump



rear wheel on the speed bump



car on the flat ground



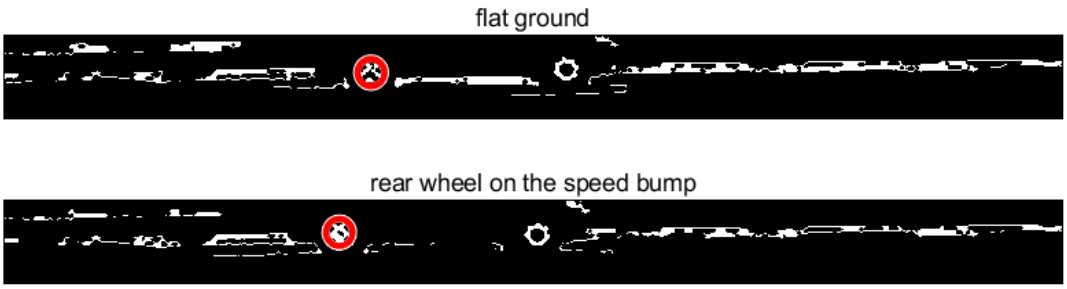
d) How much do the vehicle's wheel move in the vertical direction as it goes over the speed bump?

Pixel movement = 6.12 pixels

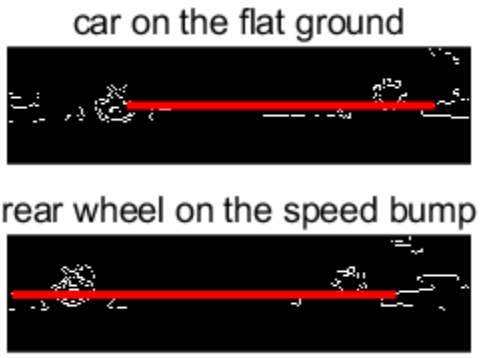
Rear wheel displacement = 6.12 x 1.25 = 7.67 cm

To calculate the vertical displacement of the wheel, we need to compare the positions of the wheel when it is on the speed bump and when it is on flat ground. We can use the Hough Transform to identify the circle of the rear wheel in both

scenarios. Cropping the frame can enhance the detection of the rear wheel. After determining the pixel movement, we will convert this measurement to centimeters.



e) How much do the vehicle's body move in the vertical direction as it goes over the speed bump?
Body displacement: 1.25 cm
To calculate the body movement of the car, we first need to determine the horizontal position of the car when it is on the speed bump compared to when it is on flat ground. We can then find the difference between these two positions.



Since the line is not perfectly horizontal (90 degrees), it is more effective to calculate the mean value of the y-coordinate along the line. This will provide a reference point for the car's body position.

f) What is the height of the speed bump?
Estimated speed bump height: 6.41 cm
To estimate the speed bump height, we use wheel movement minus car body movement. Because the body of the vehicle may experience additional movements due to suspension, while the wheels' movement directly reflects the height and shape of the speed bump. By subtracting body movement, we get a more accurate estimate of the bump's height, minimizing other factors that could skew the measurement.

g) Does the number of riders affect the vertical movement of the wheels and the body differently?

Yes, the number of riders affect the vertical movement of the wheels and the body. As the number of riders increases, the total weight of the vehicle increases, which can cause more compression in the suspension system. This can lead to more vertical movement in the body, as the suspension adjusts to the added weight. The wheel movement may slightly change as difference number of riders, but the effect on the wheels is usually less dramatic compared to the body.