# CHAPTER 4 FIELD OBSERVATIONS

To identify the significant factors affecting the interaction of motorcycles and other vehicles in mixed traffic, this chapter conducts a field survey by observing and measuring the two-dimensional characteristics for all the vehicles at a constant time step. Section 4.1 describes the data collection method. Sections 4.2 through 4.5 present the results of our observations. Finally, a summary is addressed in section 4.6.

## 4.1 Data Collection

For simplicity, our observation area has no influences from the upstream and downstream intersections, nor affected by other interruptions including bus stops or pedestrian crossing. The field survey was conducted in the southbound section of Tunhua South Road between Padeh Road and Civil Boulevard in Taipei City. The observed road section is a divided slow-traffic-lane of ten-meter width. Traffic composition on which contains only two vehicle types, car and motorcycle. Curb parking is prohibited in this observed section. The geometry of the survey site is depicted in Figure 4-1.

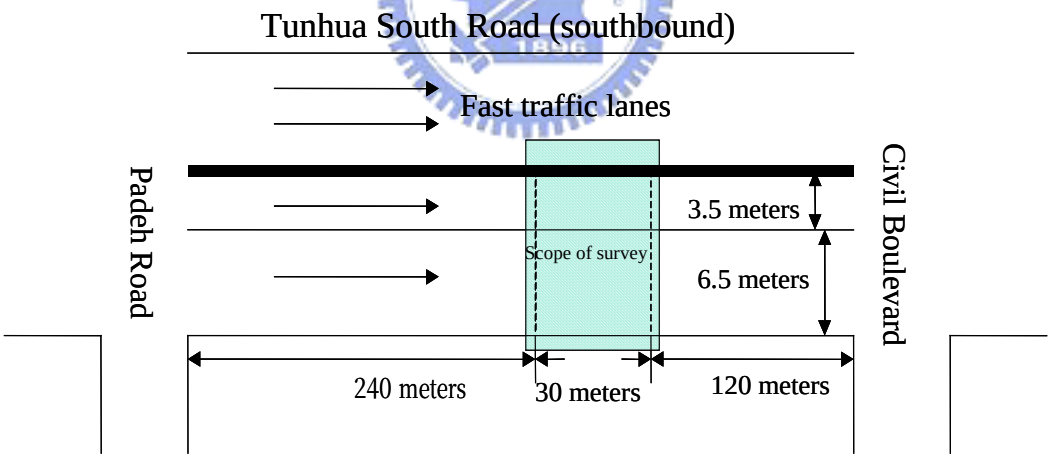


Figure 4-1 Location of observation

This study uses a video camera to record the flow scenes during 8:00-9:30am and 16:00-17:30pm in which the flow rates range from 2,100 to 2,900 vehicles (including cars and motorcycles) per hour. A total of 3,064 motorcycles-related samples are observed. There is an alley at the upstream of investigated location. Because of only 15 vehicles passing in and out the alley in investigated period,

the impacts of these vehicles are ignored. The videotape is imposed synchronously with a timer where traffic data can be recorded to 0.01 second. Figure 4-2 demonstrates the time-space relationship of data recording from the video. X-axis represents the direction of motorcycles' moving and Y-axis represents motorcycle's lateral displacement. Ju's study (1999) has shown that the reaction time for a motorcyclist is about 0.4 – 0.6 second, thus this update related vehicle's coordinates on the screen every 0.5 second and then convert these coordinates to real locations in the field. The maximum error of X and Y coordinates on the screen is 0.05 cm, which is equivalent to maximum distance error of 3.70 cm or maximum velocity error of 0.532 kph for the field observation.

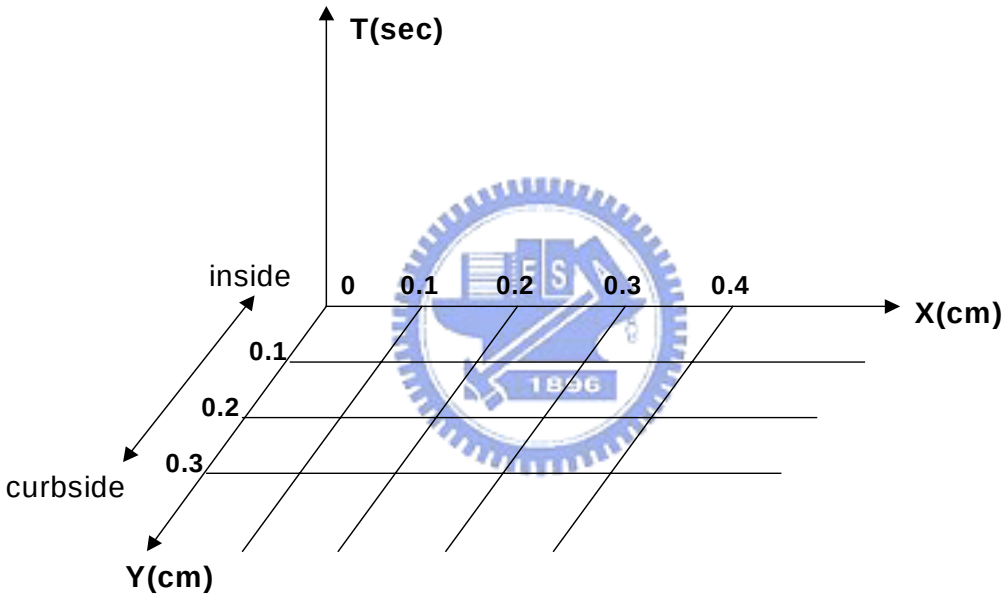


Figure 4-2 Time-space recording for motorcycle motion

Based on the recorded data (i.e. X and Y coordinates), this study can measure the longitudinal and lateral positions, lateral position displacements, speeds, acceleration rates and gaps between motorcycle and neighboring vehicles as following equations.

1. Longitudinal position for vehicle $n$ at time $t$: $X_{(n,t)} = x_{(n,t)} \times \text{scale}$;
2. Lateral position for vehicle $n$ at time $t$: $Y_{(n,t)} = y_{(n,t)} \times \text{scale}$;
3. Lateral position displacements for vehicle $n$ at $t-(t-1)$ interval: $dy_{(n,t)} = (y_{(n,t)} - y_{(n,t-1)}) \times \text{scale}$;

4. Speed for vehicle $n$ at time $t$:

$$V_{(n,t)} = \sqrt{[(x_{(n,t)} - x_{(n,t-1)})^2 + (y_{(n,t)} - y_{(n,t-1)})^2]} / 0.5 \times \text{scale};$$

5. Acceleration rate for vehicle $n$ at time $t$: $a_{(n,t)} = \frac{(V_{(n,t)} - V_{(n,t-1)})}{0.5} \times \text{scale}$

6. Gaps between neighboring vehicles at time $t$:

$$g_{(l,t)} = \sqrt{[(x_{(l,t)} - length_l - x_{(o,t)})^2 + (y_{(l,t)} + 0.5(width_l) - y_{(o,t)})^2]} \times \text{scale},$$

$$g_{(r,t)} = \sqrt{[(x_{(r,t)} - length_r - x_{(o,t)})^2 + (y_{(r,t)} - 0.5(width_r) - y_{(o,t)})^2]} \times \text{scale}$$

where, $g_{(l,t)}$ and $g_{(r,t)}$ represent the gaps between aimed motorcycle and left-front and right-front vehicle; $x_{(o,t)}$ and $y_{(o,t)}$ represent the aimed motorcycle's X and Y coordinates; $x_{(l,t)}$, $y_{(l,t)}$ and $x_{(r,t)}$, $y_{(r,t)}$ represent the neighboring vehicle's X and Y coordinates; $length_l$, $width_l$ and $length_l$, $width_l$ represent the length and width of the neighboring vehicle.

## 4.2 Sample Categories

A total of 3,064 such samples have been observed. All samples are divided into five categories with sampling states based on the relative position (see Figure 4-3) in observation area, including:

(1) Case 1: no vehicles in front, that is, motorcycle moving without any front vehicles in observation area

1,108 motorcycles belong to this category to be equal to 36.2% of all samples.

(2) Case 2: only one lead vehicle existent in front;

195 motorcycles belong to this category to be equal to 6.4% of all samples.

(3) Case 3: no lead vehicle existent in front and either left-front vehicle or right-front vehicle or both vehicles existent;

1,423 motorcycles belong to this category to be equal to 46.4% of all samples.

(4) Case 4: lead vehicles existent in front and either left-front vehicle or right-front vehicle or both vehicles existent;

227 motorcycles belong to this category to be equal to 7.4% of all samples.

(5) Case 5: obviously changing relative position.

111 motorcycles belong to this category to be equal to 3.6% of all samples.

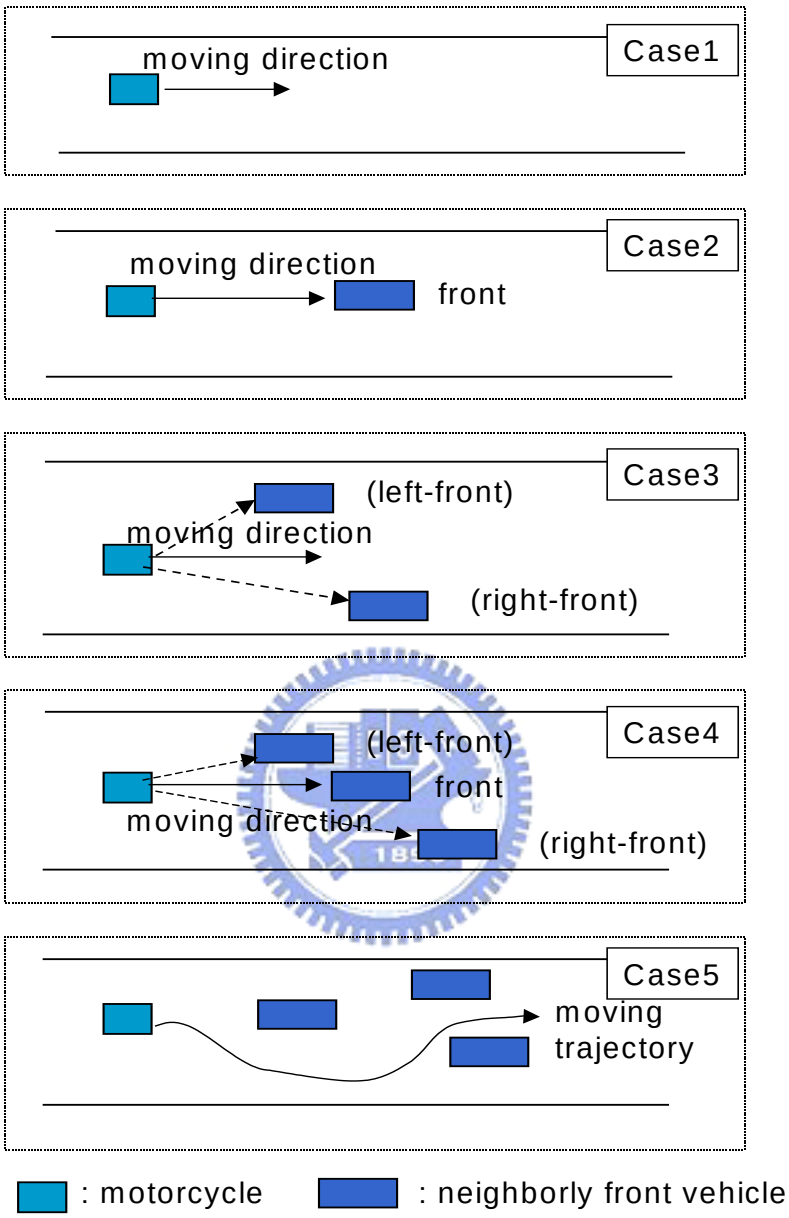


Figure 4-3 Five categories of sampling states

## 4.3 Lateral Position and Displacement Distribution

(1) Case 1

While no lead vehicle existing, 80% of these motorcycles (a total of 1,108 motorcycles) show on the curbside lane, that is, their appear usually on the lateral positions locating at distances from inside traffic island ranging

from four meters to seven meters. (see Figure 4-4).

Figure 4-5 is the latitudinal shift distributions for every time interval and overall observed interval. We find that 98% of lateral displacements for every time interval are smaller than 0.5 meters, and 75% of overall lateral displacement are smaller than 0.5 meters.

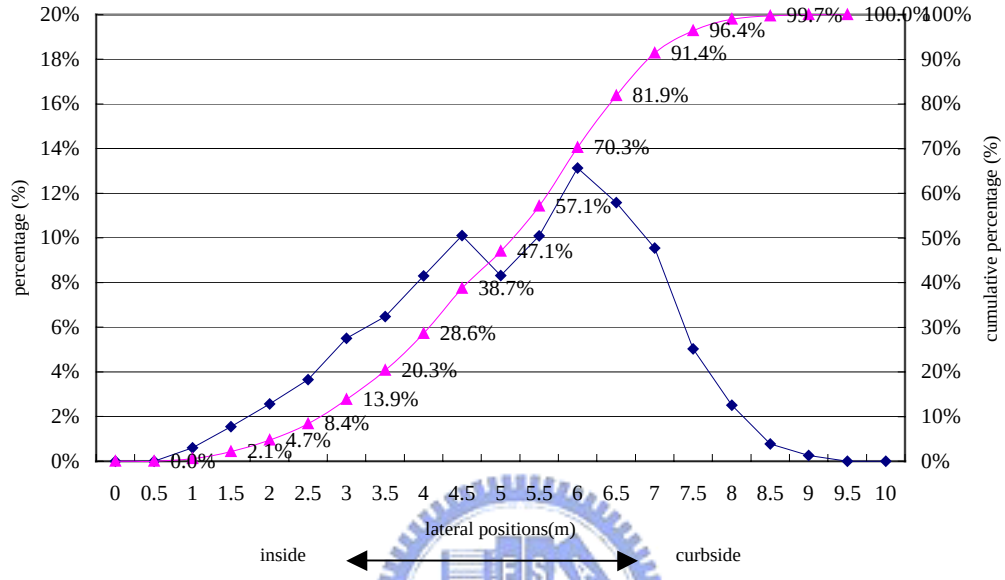


Figure 4-4 Lateral position distributions for Case 1

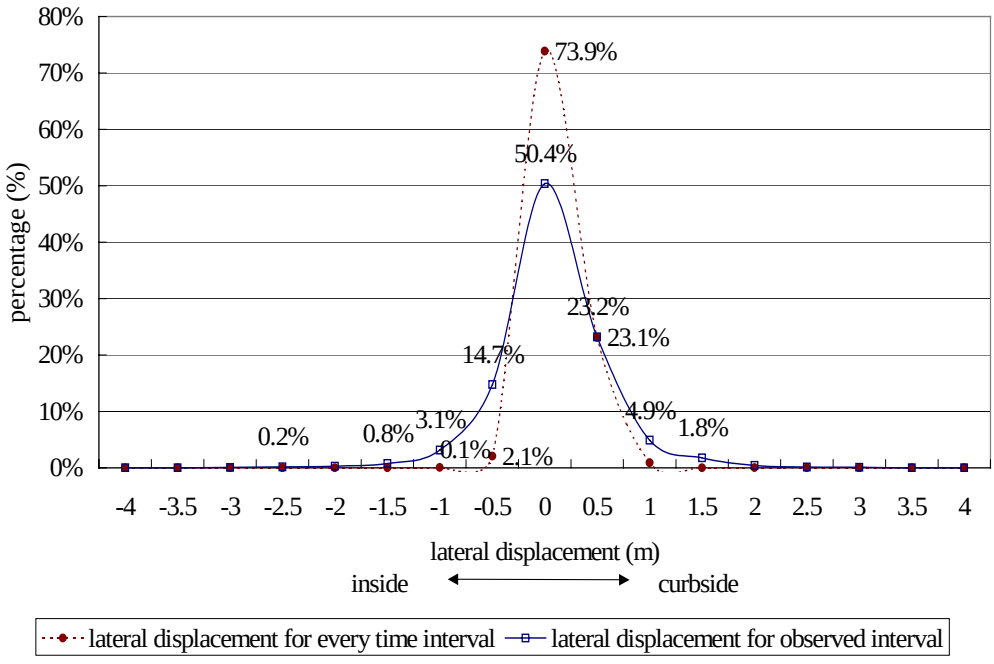


Figure 4-5 Lateral displacement distributions for Case 1

(2) Case 2

While only one lead vehicle existing, 81% of these motorcycle (a total of 195 motorcycles) show on the curbside lane, that is, their appear usually on the lateral positions locating at distances from inside traffic island ranging from four meters to seven meters. (see Figure 4-6).

Figure 4-7 is the latitudinal shift distributions for every time interval and overall observed interval. It is found that 98% of lateral displacements for every time interval are smaller than 0.5 meters, and 79% of overall lateral displacement are smaller than 0.5 meters.

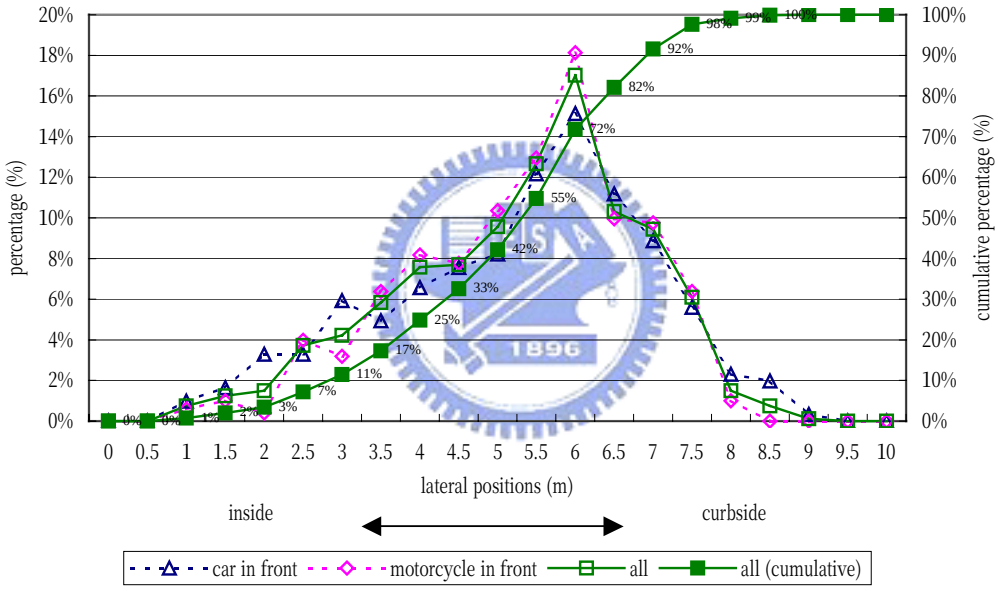


Figure 4-6 Lateral position distributions for Case 2

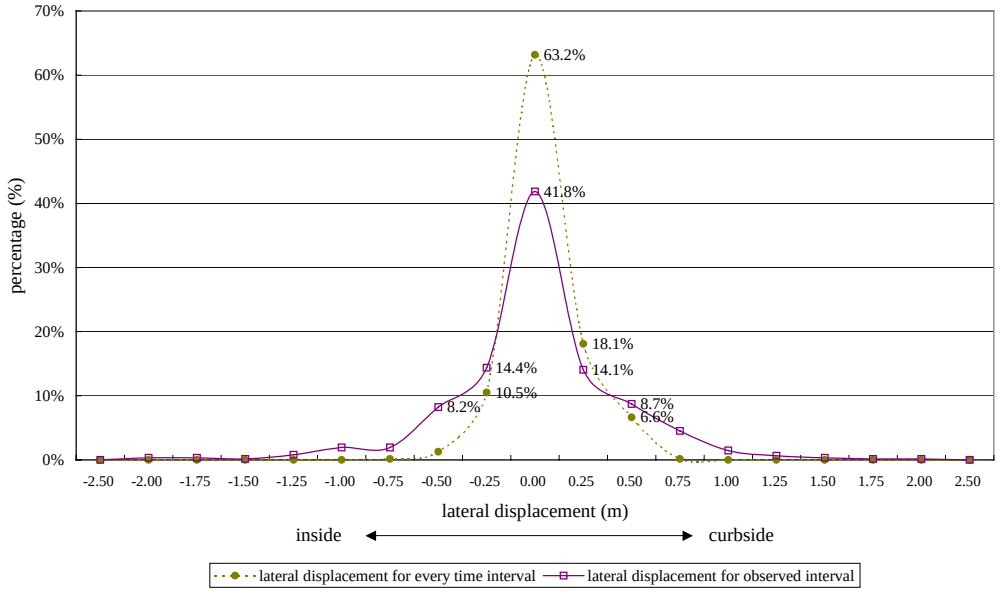


Figure 4-7 Lateral displacement distributions for Case 2

(3) Case 3

In Case 3, no lead vehicle existing in front and either left-front vehicle or right-front vehicle or both vehicles existing, 79% of these motorcycle (a total of 1,423 motorcycles) show on the curbside lane. In this Case, 784 motorcycles with left-front vehicle existing, 454 motorcycles with right-front vehicle existing and 185 motorcycles with vehicles in both left-front and right-front. The percentages of motorcycles showing on curbside lane in above-mentioned situations are 95%, 49% and 75%, respectively. (see Figure 4-8)

Figure 4-9 is the latitudinal shift distributions for every time interval and overall observed interval. It is found that 97% of lateral displacements for every time interval are smaller than 0.5 meters, and 69% of overall lateral displacement are smaller than 0.5 meters.

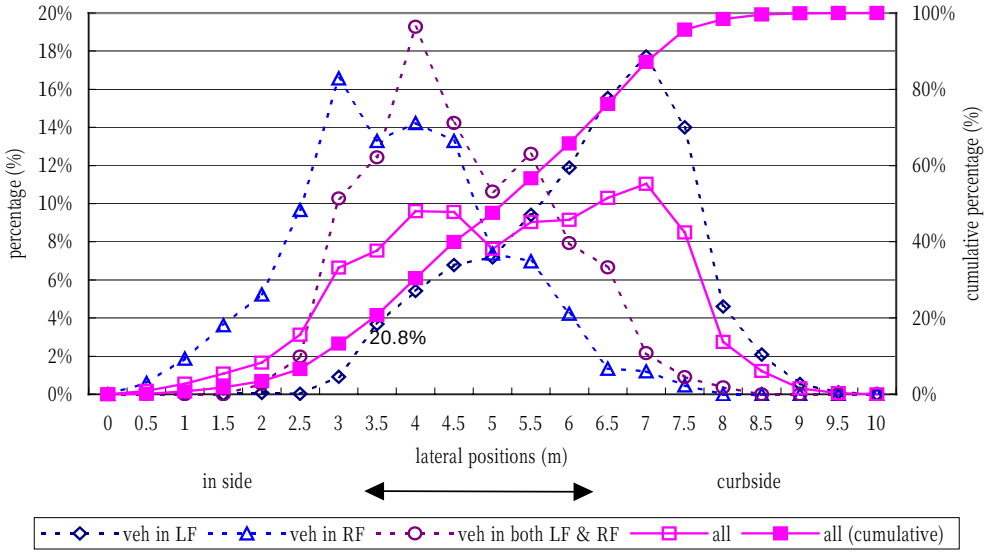


Figure 4-8 Lateral position distributions for Case 3

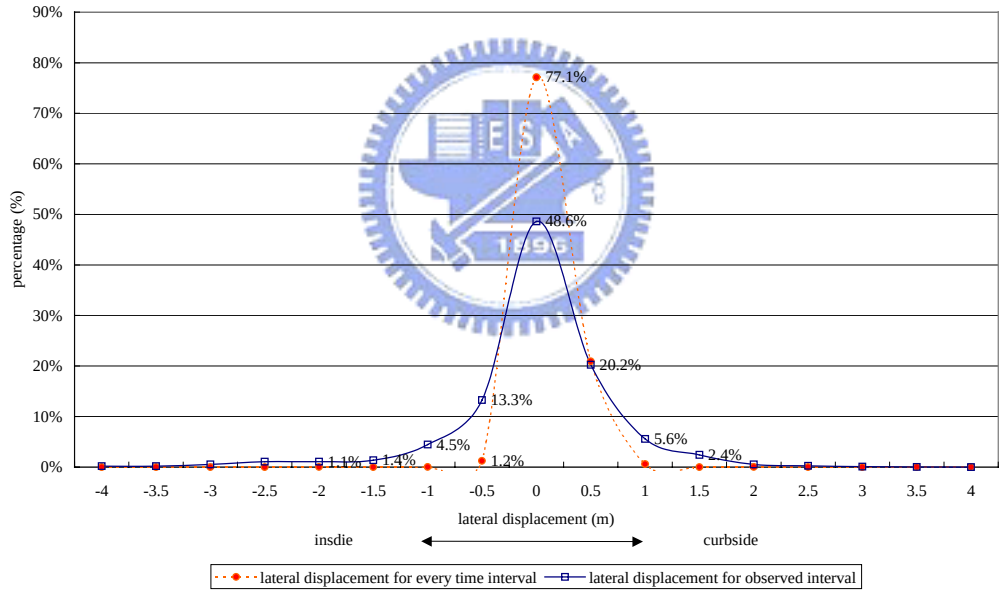


Figure 4-9 Lateral displacement distributions for Case 3

(4) Case 4

In Case 4, one lead vehicle existing in front and either left-front vehicle or right-front vehicle or both vehicles existing, 79% of these motorcycle (a total of 227 motorcycles) show on the curbside lane. In this Case, 116 motorcycles with lead and left-front vehicles existing, 89 motorcycles with lead and right-front vehicles existing and 22 motorcycles with vehicles in front, left-front and right-front. The percentages of motorcycles showing on

curbside lane in above-mentioned situations are 95%, 53% and 86%, respectively. (see Figure 4-10)

Figure 4-11 is the latitudinal shift distributions for every time interval and overall observed interval. It is found that 98% of lateral displacements for every time interval are smaller than 0.5 meters, and 87% of overall lateral displacement are smaller than 0.5 meters.

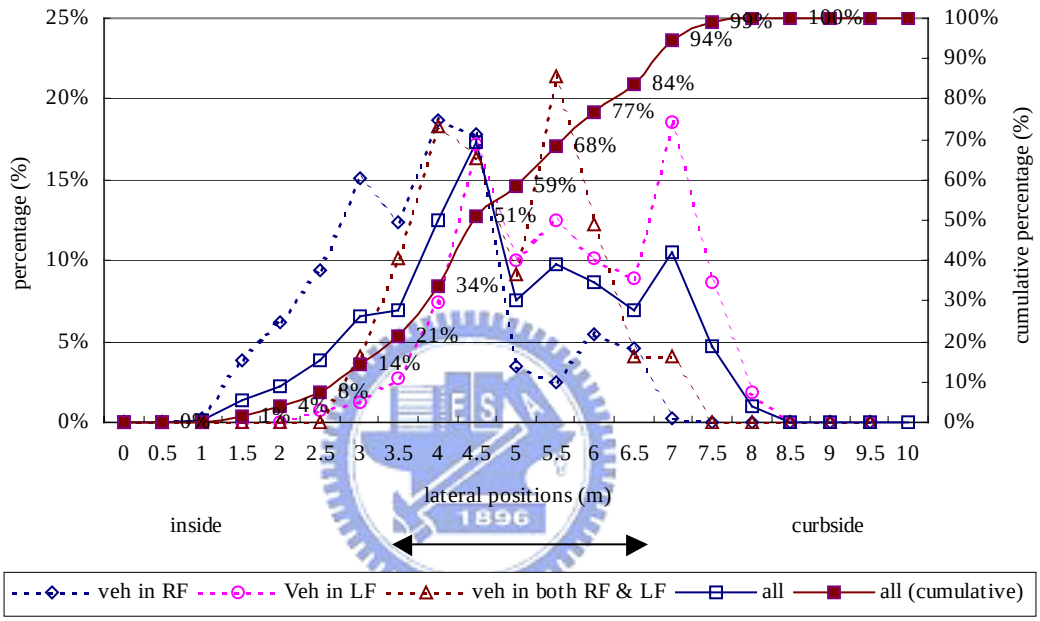


Figure 4-10 Lateral position distributions for Case 4

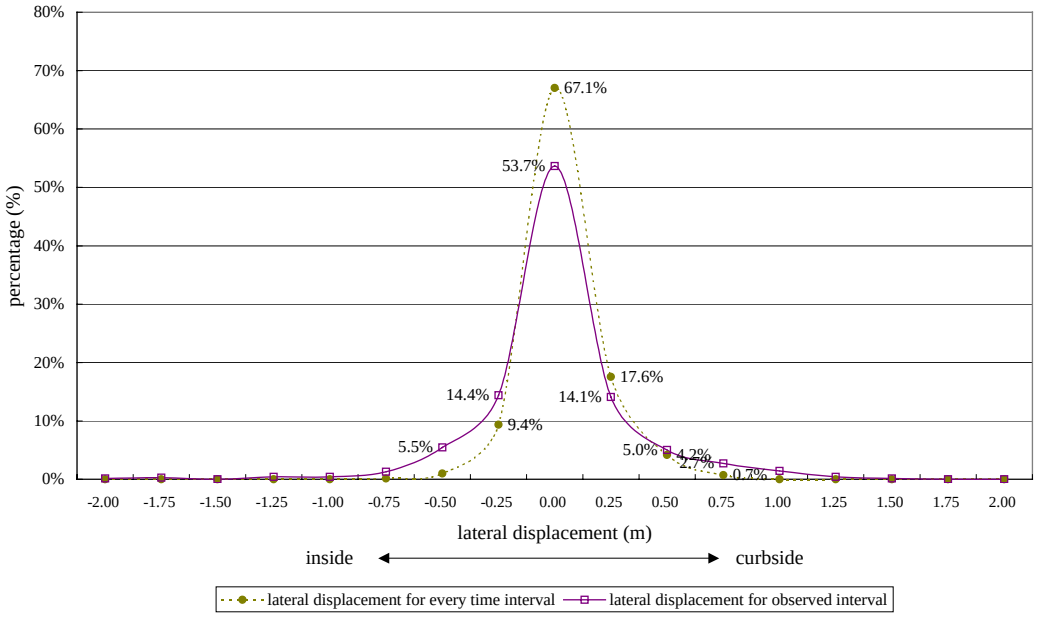


Figure 4-11 Lateral displacement distributions for Case 4

(5) Case 5

While the motorcycle obviously changing relative position, 84% of these motorcycle (a total of 111 motorcycles) show on the curbside lane. (see Figure 4-12).

Figure 4-13 is the latitudinal shift distributions for every time interval and overall observed interval. It is found that 89% of lateral displacements for every time interval are smaller than 0.5 meters, and 48% of overall lateral displacement are smaller than 0.5 meters. This phenomenon in which the lateral displacement is larger is different from above-mentioned four cases.

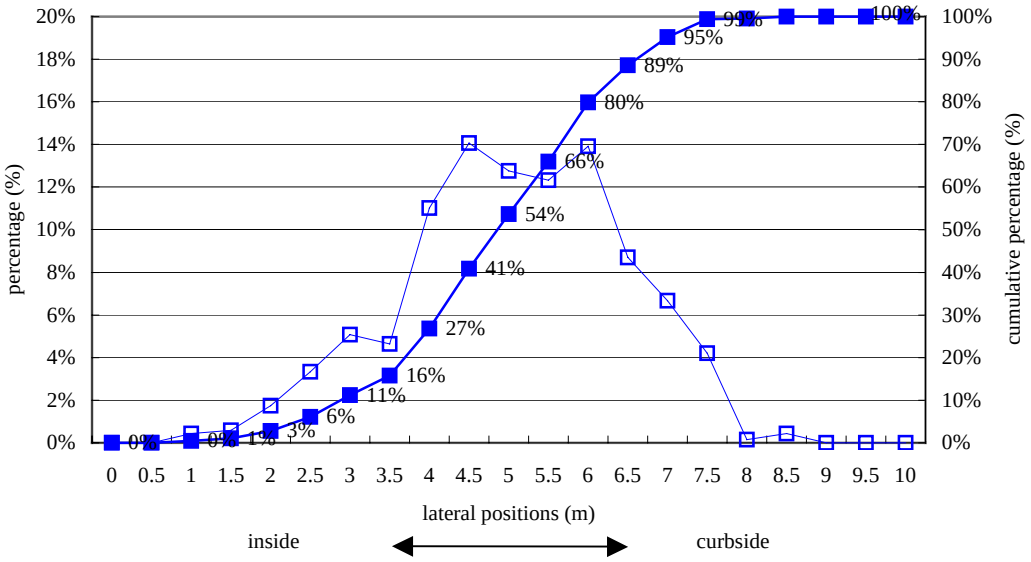


Figure 4-12 Lateral position distributions for Case 5

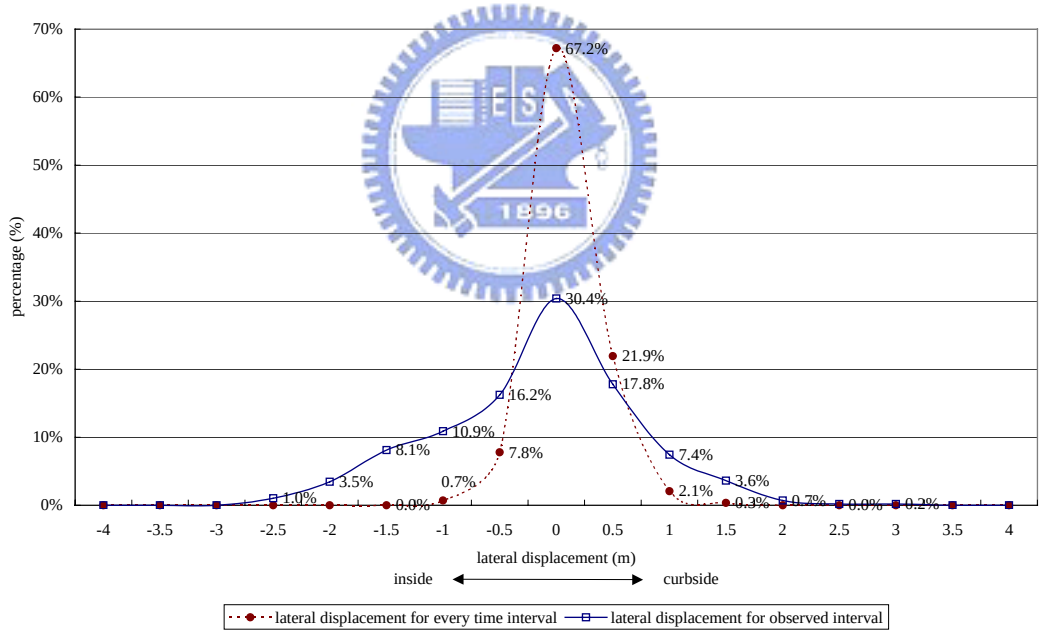


Figure 4-13 Lateral displacement distributions for Case 5

## 4.4 Speeds and Acceleration Rates Distribution

Table 4.1 shows observed speeds in various cases, which range from 12.79 kph to 82.53 kph. Both maximum and minimum speeds occur in Case 1. However, the average speeds range from 37.41 kph to 46.08 kph; the maximum and minimum average speed occur in Case 1 and Case 5, respectively. This

phenomenon explains the motorcycle in Case 1 being freer than in other cases. Figure 4-14 illustrates observed speed cumulative distributions. We could find that the trends for various are analogous, that is, most speeds occur between 30 kph and 55 kph.

Table 4.1 Observed speed for various cases

| Items | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---|---|---|---|---|---|
| Maximum speed (kph) | 82.53 | 63.71 | 75.86 | 67.96 | 65.99 |
| Minimum speed (kph) | 12.79 | 20.01 | 13.97 | 19.83 | 16.64 |
| Average speed (kph) | 46.08 | 42.19 | 43.48 | 42.32 | 37.41 |
| Standard deviation (kph) | 11.07 | 9.60 | 9.92 | 9.35 | 9.67 |

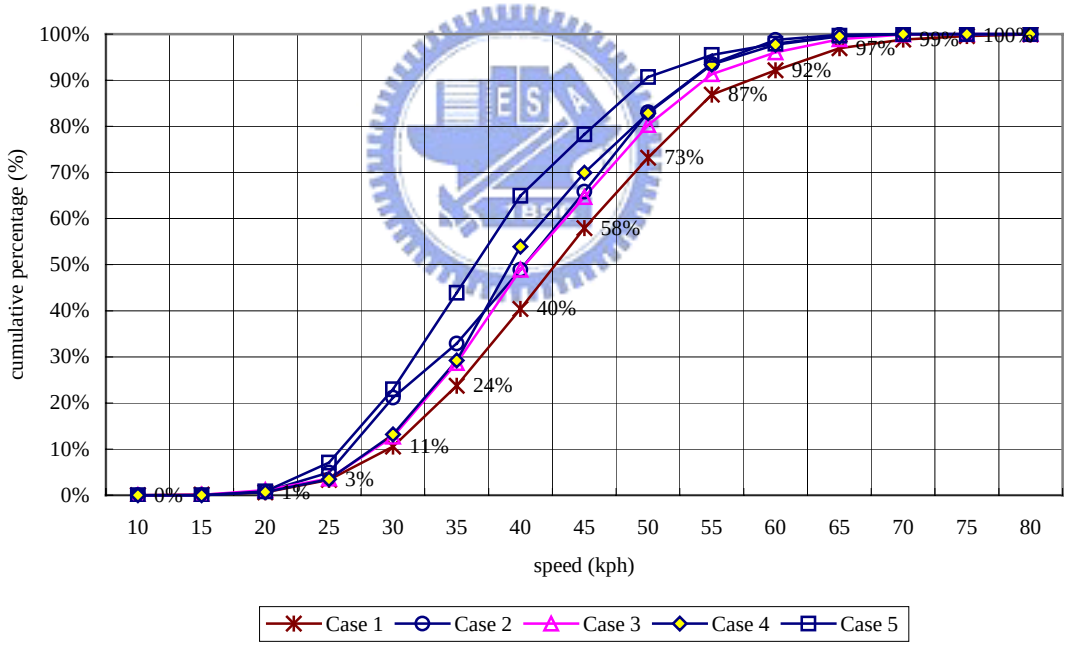


Figure 4-14 Observed speed cumulative distributions for various cases

The percentages of observed speeds below 60 kph for various cases are 92.1%, 98.8%, 96.0%, 97.8% and 97.9% in Case 1, Case 2, Case 3, Case 4 and Case 5, respectively. The majority (92%) of their acceleration (deceleration) rates are less than 1.5 m/sec$^2$ during the observation periods except acceleration rates of Case 5, in which 84.9% of acceleration rates are less than 1.5 m/sec$^2$.

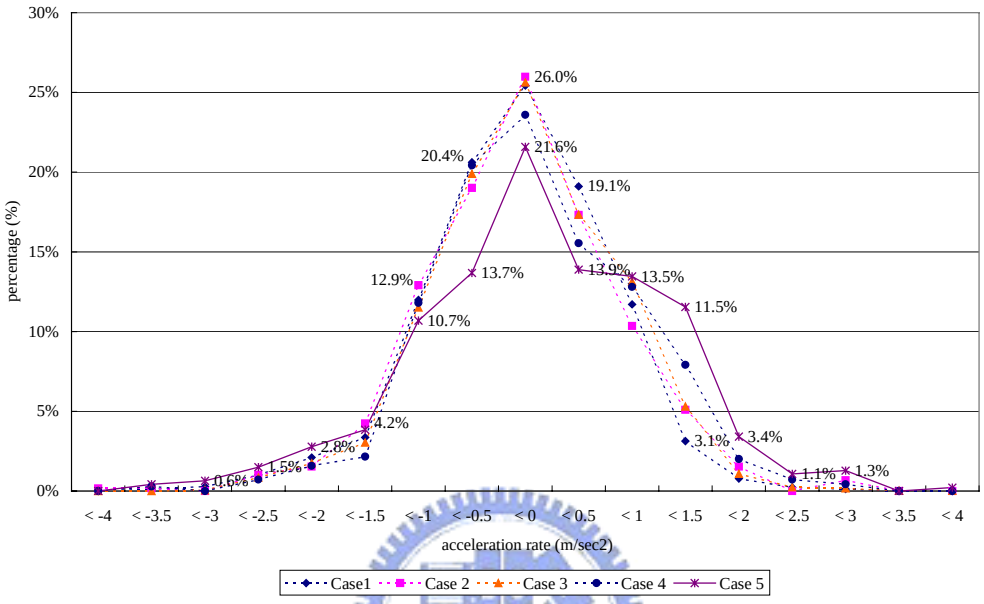


Figure 4-15 Observed acceleration rate distributions for various cases

## 4.5 Gaps between Motorcycle and Neighboring Vehicles

The gaps between motorcycle and neighboring vehicles are discussed in this section. Table 4.2 shows the observed gaps for Case 2~ Case 5. Figure 4-16~4-19 illustrate the distributions of gaps between neighboring vehicles It is found that gap between in-front car and aimed motorcycle is larger than gap between in-front motorcycle and aimed motorcycle. While a motorcycle in front of aimed motorcycle, the minimum gap is around 0.5 meters; however, the minimum gap between in-front car and aimed motorcycle is around 1.3 meters. The minimum gaps for motorcycles and neighboring vehicles which are in left-front and right-front are around 0.5 meters. Generally speaking, the gap for right side is smaller than that for left side.

However, in Case 5, the minimum gaps between motorcycle and neighboring vehicles range 0.15 to 0.3 meters, the variation of gaps distribution is wider than the other cases. The phenomenon reveals that the more obvious variation of gap in changing relative position process.

Table 4.2 Gaps between motorcycle and neighboring vehicles

| Case | States | Observed numbers | Maximum value (m) | Minimum value (m) | Average value (m) | Standard deviation (m) |
|---|---|---|---|---|---|---|
| Case 2 | Motorcycle in front | 368 | 18.85 | 0.52 | 6.60 | 3.63 |
| | Car in front | 221 | 17.74 | 1.28 | 7.63 | 3.52 |
| Case 3 | Motorcycle in left-front | 1708 | 20.37 | 0.44 | 3.80 | 3.06 |
| | Car in left-front | 2616 | 23.29 | 0.48 | 3.46 | 2.95 |
| | Motorcycle in right-front | 1556 | 15.90 | 0.44 | 3.15 | 2.68 |
| | Car in right-front | 1111 | 20.41 | 0.44 | 2.82 | 2.81 |
| Case 4 | Motorcycle in front | 434 | 17.37 | 0.74 | 6.97 | 2.97 |
| | Car in front | 258 | 18.93 | 1.37 | 7.17 | 3.28 |
| | Motorcycle in left-front | 147 | 10.60 | 0.50 | 3.08 | 2.29 |
| | Car in left-front | 241 | 11.56 | 0.48 | 3.09 | 2.38 |
| | Motorcycle in right-front | 161 | 11.46 | 0.50 | 2.42 | 1.78 |
| | Car in right-front | 107 | 13.43 | 0.51 | 1.78 | 1.62 |
| Case 5 | Motorcycle in front | 194 | 12.57 | 0.16 | 4.18 | 2.44 |
| | Car in front | 186 | 21.37 | 0.30 | 6.23 | 4.27 |
| | Motorcycle in left-front | 170 | 11.61 | 0.15 | 4.06 | 2.78 |
| | Car in left-front | 175 | 16.63 | 0.21 | 3.69 | 3.45 |
| | Motorcycle in right-front | 173 | 15.16 | 0.30 | 3.57 | 2.78 |
| | Car in right-front | 175 | 21.37 | 0.20 | 3.67 | 3.69 |

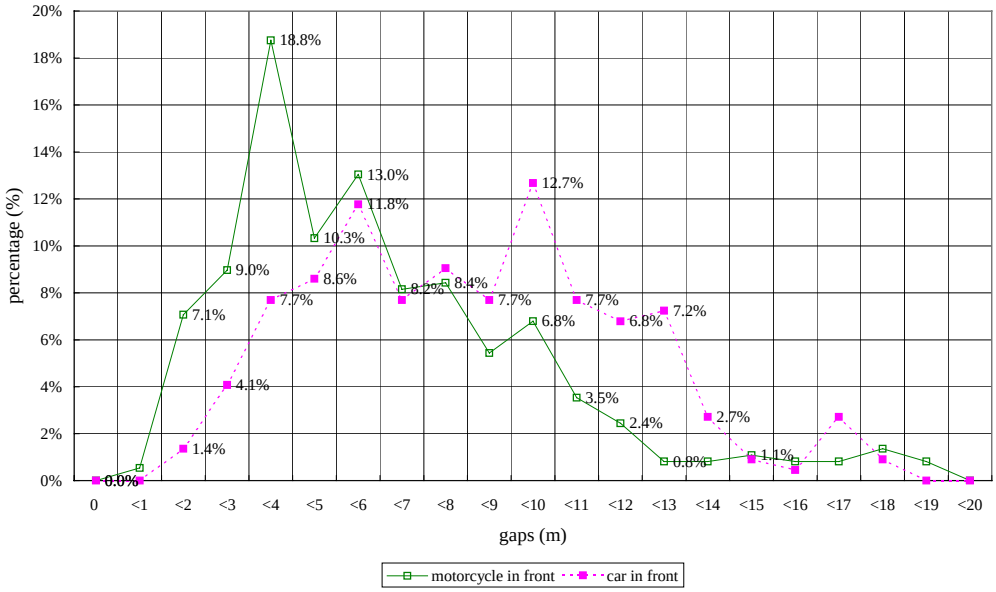


Figure 4-16 Gaps between motorcycle and in-front vehicle for Case 2

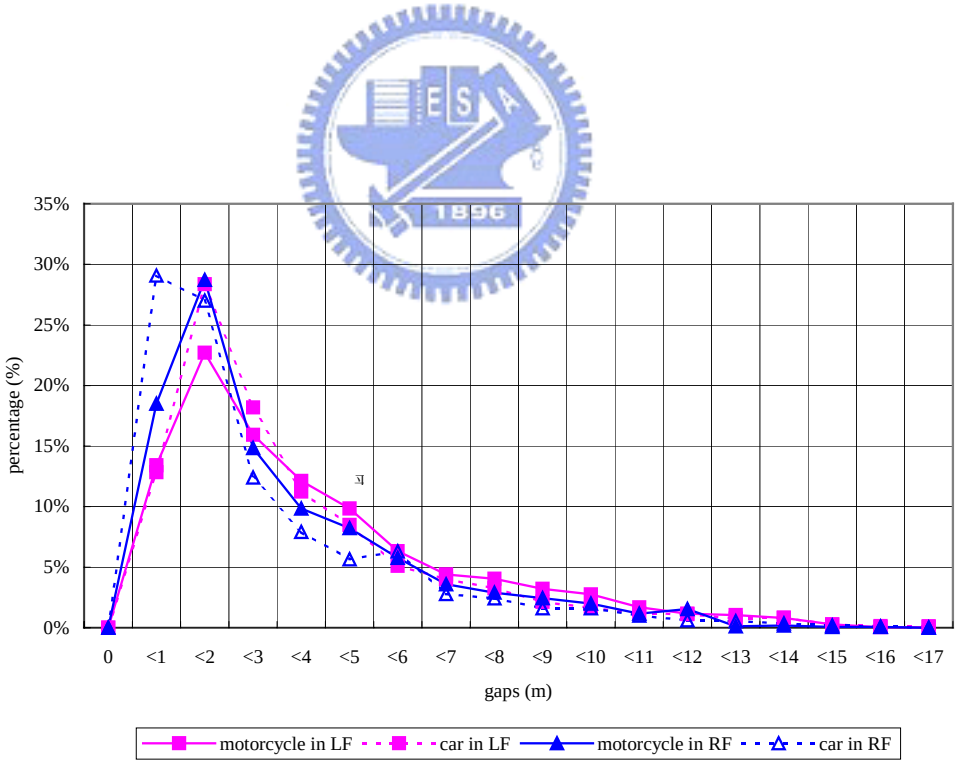


Figure 4-17 Gaps between motorcycle and neighboring vehicles for Case 3

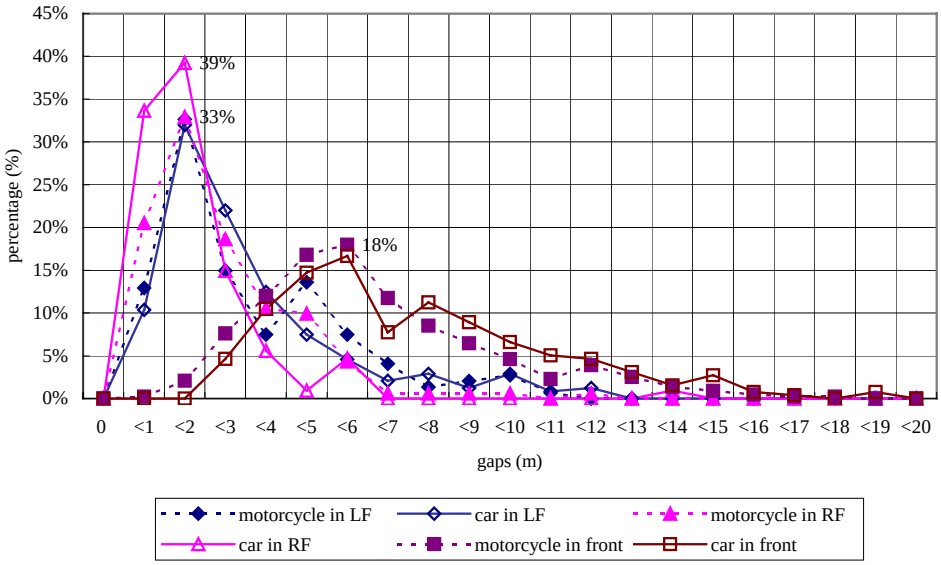


Figure 4-18 Gaps between motorcycle and neighboring vehicles for Case 4

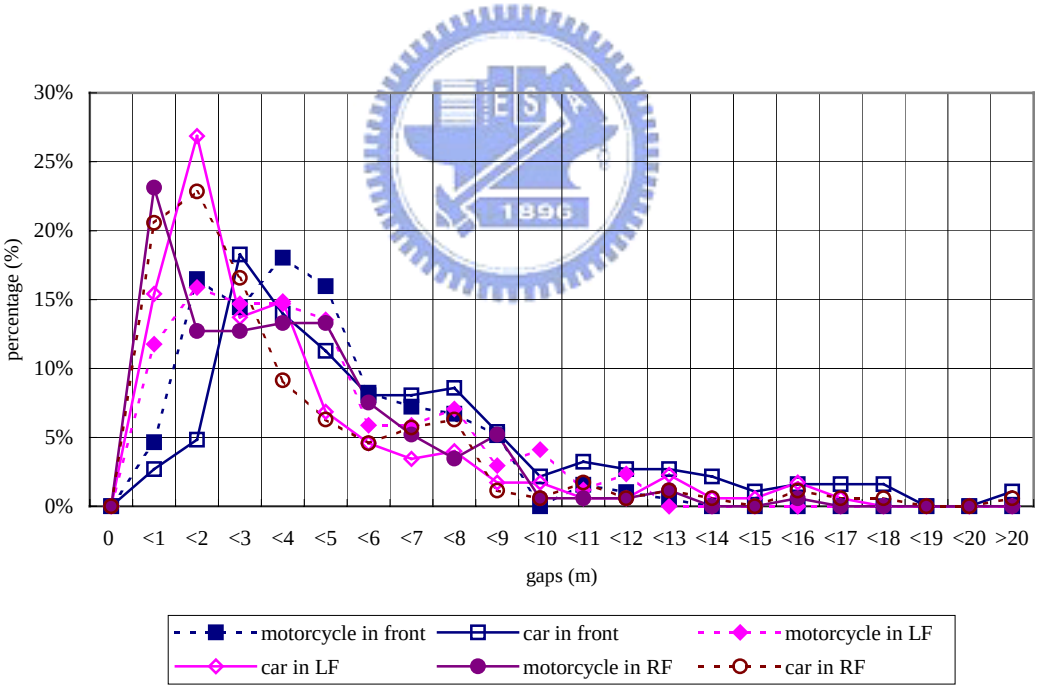


Figure 4-19 Gaps between motorcycle and neighboring vehicles for Case 5

## 4.6 Summary

The characteristics of the field observation for various categories are summarized as table 4.3.

Table 4.3 Characteristics of various categories

| Category / Behavior | Case 1 (n=1,108) | Case 2 (n=195) | Case 3 (n=1,423) | Case 4 (n=227) | Case 5 (n=111) |
|---|---|---|---|---|---|
| Latitudinal distribution | 80% in curbside lane | 81% in curbside lane | 79% in curbside lane | 78% in curbside lane | 84% in curbside lane |
| Lateral displacement per time step | 98%<0.5m | 98%<0.5 m | 97%<0.5 m | 98%<0.5 m | 89%<0.5 m |
| Average Speed | 46.08 kph (92%<60) | 42.19 kph (99%<60) | 43.48 kph (96%<60) | 42.32 kph (98%<60) | 37.41 kph (98%<60) |
| Average gap with other vehicles | — | F:6.86 m | L:3.59 m R:3.01 m | F:6.60 m L:3.09 m R:2.16 m | F:5.18 m L:3.87 m R:3.61 m |
| Minimum gap with other vehicles | — | F:0.52 m | L:0.48 m R:0.44 m | F:0.74 m L:0.48 m R:0.50 m | F:0.16 m L:0.15 m R:0.20 m |
| Acceleration rate ($m/s^2$) | max: 3.46 min: -2.94 (92%<±1.5) | max: 2.93 min: -4.15 (91%<±1.5) | max: 3.76 min: -3.87 (93%<±1.5) | max: 2.91 min: -2.97 (92%<±1.5) | max: 3.84 min: -3.59 (85%<±1.5) |

Notes: F, L, R indicate in front side, left-front side and right-front side respectively.

More than 75% of the observed motorcycles have traveled along the curbside. They appear within 5.0-7.0 meter, measuring from the separated island, in the 10-meter width slow lane. Over 90% of them have lateral displacement per time step less than 0.5 meters within the observation range of 30 meters. The average gaps between lead vehicle and the following motorcycle is about 6~7 meters; the average gaps between left-front (or right-front) and the following motorcycle are 3~3.9 (or 2~3.6) meters. 80% of the total observations have traveled at speed ranging from 25 to 55 km/h. And the great majority of speeds, over 92%, are below 60 kph. Besides, only 422 motorcycles (13.8%) are found with "following" behaviors, the others (86.2%) are obviously like "sneaking" or "lane-changes" because their moving paths are either in between two adjacent vehicles or with lateral displacements greater than 0.5 meters.