CHAPTER 4 DATA FOR CALIBRATION AND VALIDATION

To recognize the performance of the proposed incident detection algorithms, this chapter conducts the simulated data by Paramics for network training and algorithms evaluation. A real but short-lasting traffic incident during a weekday afternoon rush hour is deliberately experimented to fine-tune the Paramics to fix the real traffic environment and then the calibrated Paramics is used to generate adequate data for the empirical studies. Section 4.1 demonstrates the field observation and the schematic geometry of freeway segment. Section 4.2 describes the calibration of Paramics with a real incident. Section 4.3 presents the different incident scenarios and some simulation results for validation of incident detection algorithms.

4.1 Field Observation

It is very difficult to generate sufficient real traffic incidents to validate any AID algorithm. Thus, most previous algorithms adopt off-line validations by simulation or incident database. To collect traffic data associated with a real incident so as to calibrate the traffic simulator – Paramics, under special permission from the Taiwan Freeway Authority, Lan, *et al.*, (2004) deliberately generated a real traffic incident by placing two cars at 19K+400, northbound of Taiwan Freeway No. 1, so as to block the shoulder and outer lane of the two-lane freeway mainline section by allowing only one lane (inner) for traffic passing through. The geometry of the experimental freeway segment is schemed in Figure 4-1, in which no on-ramp or off-ramp exists between the nearest upstream (21K+300) and downstream (18K+400) CCTV cameras in site. The upstream and downstream traffic image data are concurrently recorded by the video cameras, 15 minutes prior to, during, and after this experimented incident, respectively. Such recorded traffic images are then analyzed frame by frame (per 0.1 second) and converted to 30-second traffic data (speed, flow and density) and used for Paramics calibration.

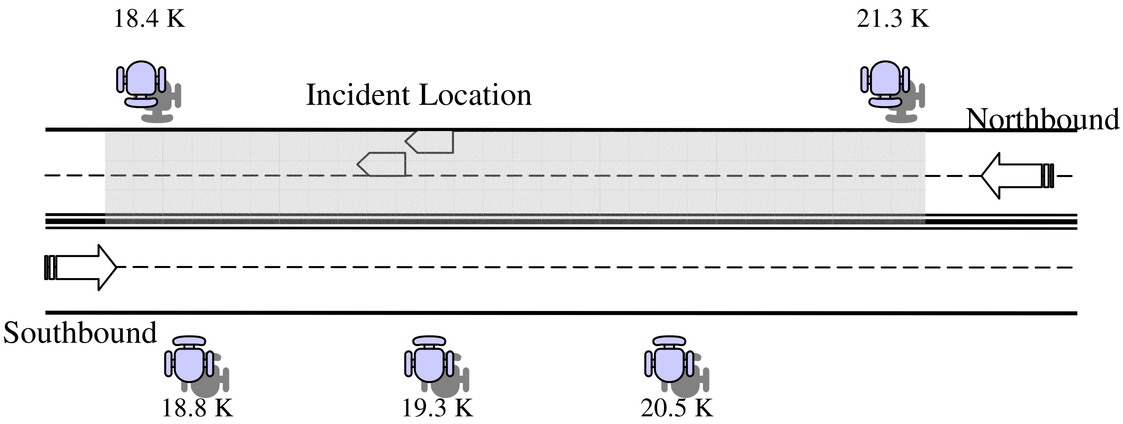


Figure 4-1 The schematic of the incident case on Taiwan Freeway No. 1

(shadow indicates the experimental section where incident took place at 19.3K and traffic data were observed at downstream 18.4K and upstream 21.3K)

Table 4-1 reports the observed traffic characteristics including lane-specific as well as overall speeds, flows and densities are drawn from the videotapes and used for calibrating the traffic simulator--Paramics. Note that the above densities are not directly measured from the detectors, but indirectly calculated from the detected flows and speeds. It also shows the tests for the difference between inner lane and outer lane. It reveals that speeds have no significant difference, but flows and densities have significant difference between inner and outer lane. It is found that the density of inner lane is higher than outer lane. Thus it is recommendable to examine the lane-specific incident detection performance.

Table 4-1 Test for difference between inner lane and outer lane

Time	Parameter[1]	Overall[2]	Inner	Outer	t value	P value	Test result[3]
15 mins before incident	**Speed**	80.47	81.08	79.87	1.2671	0.0912	NSD
	Flow	3,304	1,856	1,448	2.6412	0.0342	SD
	Density	20.54	22.91	18.16	3.6852	0.0061	SD
15 mins during incident	**Speed**	62.27	63.27	61.28	0.9872	0.8537	NSD
	Flow	2,656	1,664	992	3.5138	0.0077	SD
	Density	21.43	26.52	16.33	3.9215	0.0025	SD
15 mins after incident	**Speed**	68.23	68.53	67.93	0.6950	0.9626	NSD
	Flow	3,272	1,804	1,468	3.3186	0.0199	SD
	Density	23.95	26.32	21.58	3.9618	0.0017	SD
Total experiment 45 mins	**Speed**	70.30	70.96	69.63	0.8387	0.6900	NSD
	Flow	3,078	1,775	1,303	2.8531	0.0087	SD
	Density	21.97	25.25	18.69	2.2926	0.0452	SD

Note (1) The data represent average values of downstream traffic flow parameters. Unit of speed: kilometer/hour, flow: vehicle/hour and density: vehicle/kilometer.

(2) The speeds and densities represent the average values and flows show the summarized data.

(3) Null hypothesis H_0: $\mu_{inner}=\mu_{outer}$ and significance level α=0.05.

NSD represents no significant difference and SD represents significant difference

4.2 Paramics Calibration

The deliberate incident case mentioned above is only used for calibrating the traffic simulator not for the incident performance validation. The origin-destination pattern, arrival distribution, mixed traffic ratio, driver familiarity, incident duration, and so on are fine-tuned until the Paramics simulation results can best fit the observed data for each 15-minute period. After that, the ten simulation runs are generated for the comparison with the observed data as indicated in Table 4-2. The statistical tests conclude that there is no significant difference between the observed and simulated data for each 15-minute period, suggesting that the Paramics has been calibrated and can be employed for further simulation.

Table 4-2 Test for difference between observed and Paramics simulated data

Time	Parameter[1]	Observed	Simulated[2]	t value	P value	Test result[3]
15 mins before incident	**Speed**	80.47	83.70	1.3077	0.1997	No significant difference
	Flow	3,304	3,216	-1.8728	0.0869	No significant difference
	Density	20.54	19.36	-1.5811	0.1890	No significant difference
15 mins during incident	**Speed**	62.27	64.98	1.6912	0.1039	No significant difference
	Flow	2,656	2,732	-0.2202	0.9609	No significant difference
	Density	21.43	21.02	0.1414	0.8884	No significant difference
15 mins after incident	**Speed**	68.23	72.16	1.7797	0.0892	No significant difference
	Flow	3,272	3,192	-1.5624	0.1091	No significant difference
	Density	23.95	22.12	-1.0389	0.1563	No significant difference
Total experiment 45 mins	**Speed**	70.30	73.61	1.6867	0.1080	No significant difference
	Flow	3,078	2,964	-0.0822	0.9354	No significant difference
	Density	21.97	20.11	-1.4554	0.1619	No significant difference

Note (1) The data represent average values of downstream traffic flow parameters. Unit of speed: kilometer/hour, flow: vehicle/hour and density: vehicle/kilometer.

(2) Paramics simulated data is the average of 10 simulation runs.

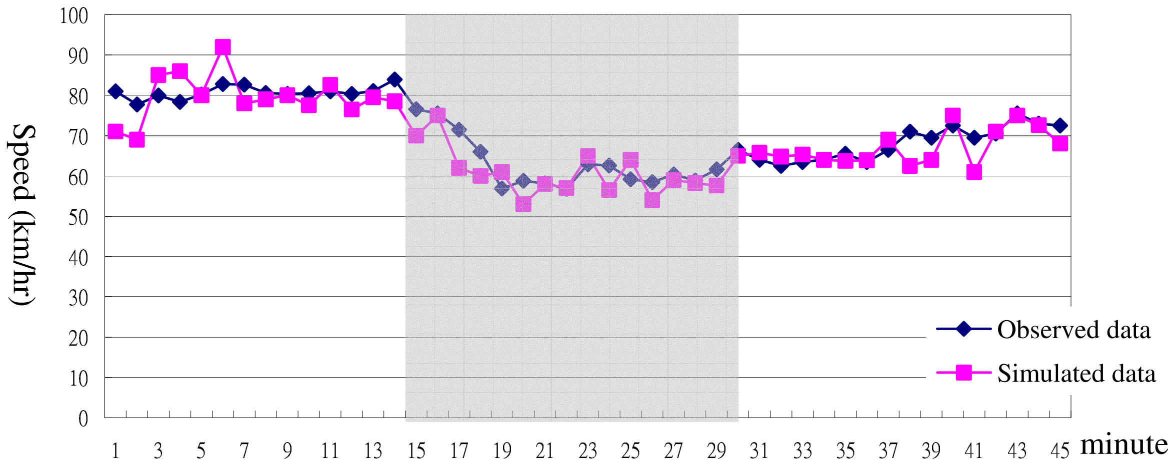
(3) Null hypothesis H_0: $\mu_{observed}=\mu_{simulated}$ and significance level α=0.05.

4.3 Simulation Scenarios and Results

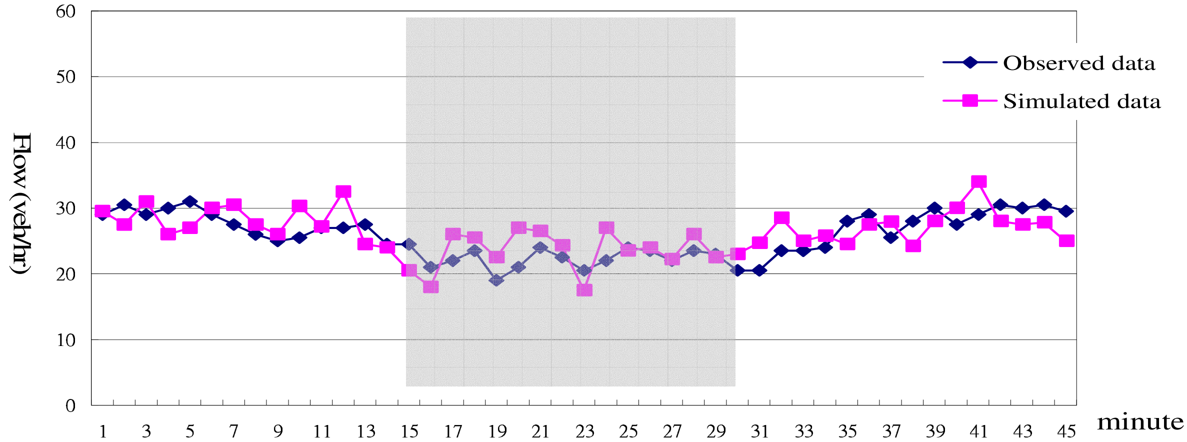
The calibrated Paramics is employed to produce the simulated incidents and incident-free data for performance validation. All simulation runs are divided into two categories based on the different traffic condition.

(1) Typical peak hours

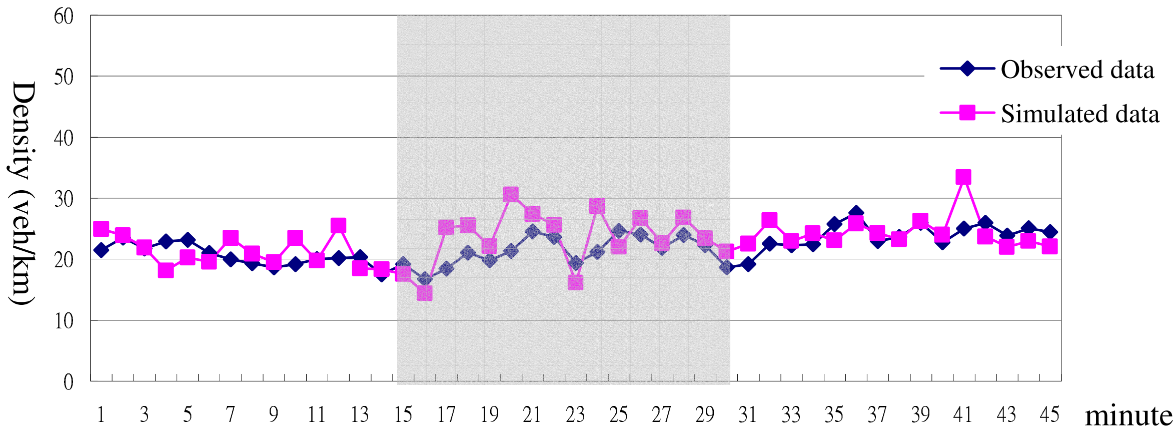
Thirty-second traffic flow data are collected in 45 minutes at the same site where the deliberate incident was experimented. The data cover a typical afternoon peak hours is used for the input traffic data of Paramics. As an example, Figure 4-2 demonstrates the 30-second flow, speed, and density variations of both incident-free and incident conditions for one scenario where the incident lasts for 15 minutes.



(a) Speed



(b) Flow



(c) Density

Figure 4-2 Comparison of observed data and simulated data

(shadows: incident duration 15 minutes)

A total of 21 scenarios are designed considering the incidents taking place in different lanes (inner/center/outer), in different incident severity (one or two lane blocked, and incident duration is 15 minutes), and at different locations (250, 500, or 750 meters from the upstream detectors). Each scenario has 200 sets of simulation data, 100 of which are used for training, and the other 100 for off-line validation. The interval of detection time is set as 30 seconds and 60 seconds.

(2) Two off-peak hours

Thirty-second traffic flow data are collected from 6:00 to 12:00 at the same site where the deliberate incident was experimented. The data cover a typical morning peak hours and two off-peak periods before and after that peak. Figure 4-3 presents the 30-second flow variations for six hours, in which conspicuous fluctuations and manifest changes in traffic volume (from low to intermediate to heavy volumes and then from heavy to intermediate to low volumes) are found. Such drastic variations suggest the necessity of renewing the network parameters in response to the most up-to-date traffic conditions through the rolling trained procedure.

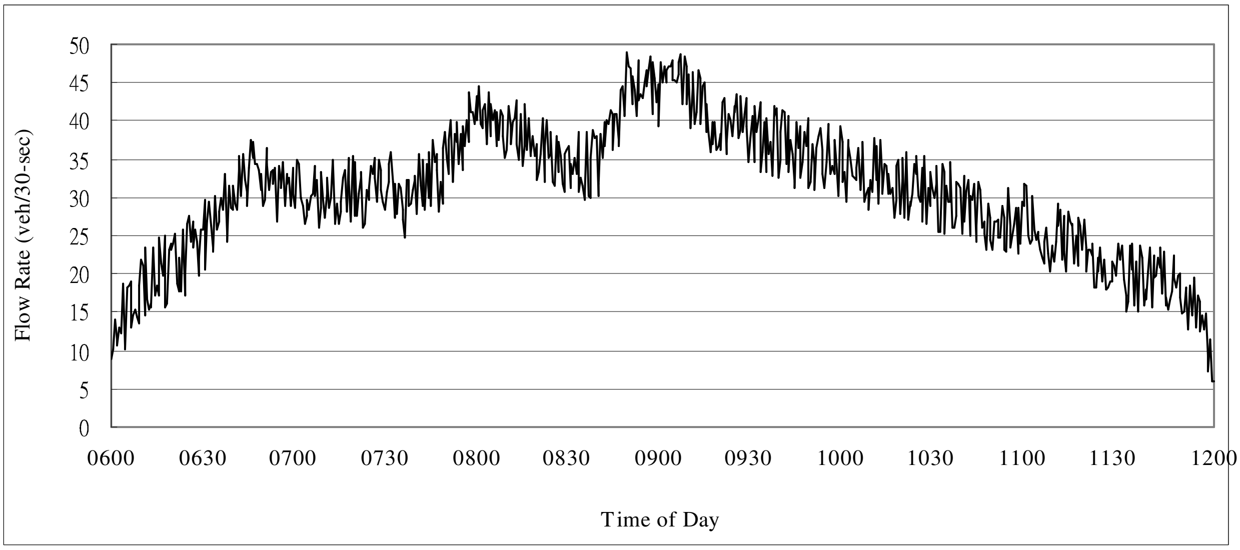


Figure 4-3 Observed 30-second flow rates on the studied freeway (two-lane mainline)

The experimental design of the following simulation places two detection points (upstream and downstream), one kilometer apart, in this two-lane freeway mainline. In between, various incident scenarios are generated, which include 36 incidents taking place in different lanes (inner and outer) at different locations (250, 500 and 750 meters from the upstream detectors) under six different traffic conditions (from light to intermediate to heavy traffic and then from heavy to intermediate to light traffic). In each scenario, Paramics also generates 200 sets of simulation data--100 of which are used for network training (called training sets) and the rest 100 sets are used for validation (called evaluation sets). As an example, Figure 4-4 demonstrates the 30-second flow variations of both incident-free and incident conditions for one scenario where the incident occurs at 7:30am and lasts for 15 minutes.

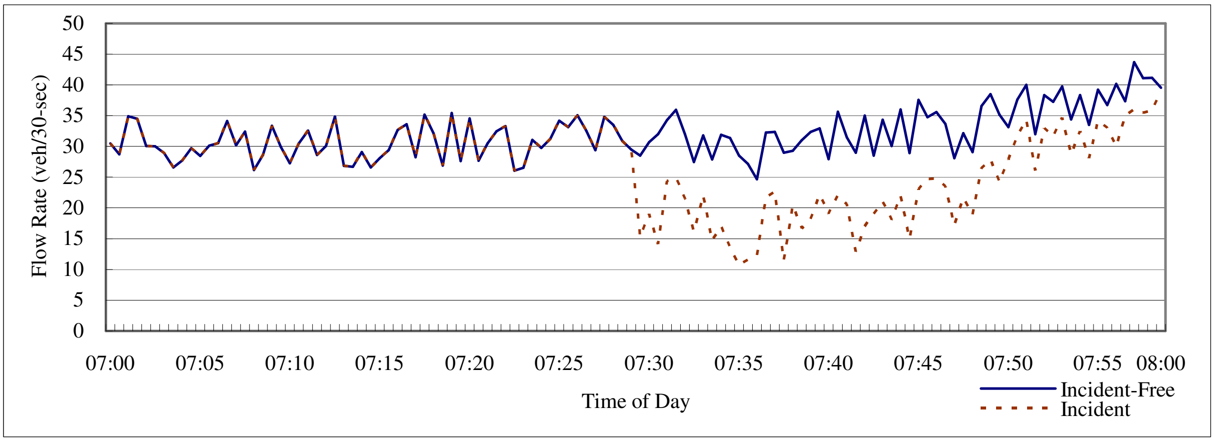


Figure 4-4　Flow variation for one incident scenario

(incident duration 7:30 am – 7:45 am)