Toward the Systematic Diagnosis of Freeway Bottleneck Activation

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Objectives (目标)

- Define bottleneck (定义)
- Definitively identify bottleneck activation (决定瓶颈开始地点)
- Measure queue discharge features (车队长特性)
- Examine potential bottleneck signals (瓶颈形成征兆)
- Conclusions (结论)
Bottleneck Definition

- Queue upstream
- Freely-flowing traffic downstream
- Temporally and spatially variable

![Diagram showing bottleneck with queued and unqueued traffic]
Site Map (地点图)
Loop Detector Data

$N(x,t)$

Flow

$N(x,t)$

$N(x,t)$

Time, $t @ x$
Methodology (理论方法)

![Diagram showing travel direction and reference vehicle trip time](image)
Methodology

Excess Accumulation

Delay

N \( (x_1,t) \)

N \( (x_2,t) \)

Ref. Veh. Trip Time

Time, \( t \)

Travel Direction

X_1

X_2
Using Oblique Axis (使用变轴坐标)

\[ N(x,t) \]

\[ \text{Time, } t \]

(a)

\[ \text{Oblique } N(x,t) \]

\[ \text{Time, } t \]

(b)
Bottleneck Activation (瓶颈形成)

Detector 40
Detector 50
Detector 60
Detectors 70 & 80

Re-scaled T-curve

Detector 50
Detector 60
Detector 80
Detector 70

$t = 510$ sec/hr
Continued Presence of Queue (持续的队长)

![Graph showing continued presence of queue over time.](image-url)
**Bottleneck Discharge Features**

- *N(80,t)q_t^* = 5400 vehicles per hour
- *T(80,t) - b_0(80)t^* = 1510 seconds per hour

Time, *t*
Individual Lane Flows

Median Lane:
- Flow: 2530 vehicles per hour
- Time: 15:18:03

Center Lane:
- Flow: 1900 vehicles per hour
- Time: 15:18:23
- Total Flow: 7120 vehicles per hour

Shoulder Lane:
- Flow: 1900 vehicles per hour
- Time: 15:18:23
- Total Flow: 1890 vehicles per hour

Time, $t$
Total Bottleneck Input Flow (进入总流量)

- Time: 13:00 to 20:00
- Average Flow: 4,000 to 7,500 vehicles/hour

- Chart shows data points for average flow over time, with a peak around 16:00.
Maximum Bottleneck Input (最大输入量)

- Maximum Bottleneck Input: 8,500 vehicles/hour
- Queue arrival at detector 60: 15:19:03
- Rolling maximum flow: 8,500 vehicles/hour

Graph showing time (13:00 to 15:30) and rolling maximum flow (4,000 to 8,500 vehicles/hour) with various time intervals (40 sec, 60 sec, 80 sec, 100 sec, 120 sec Max) and maximum flow limits.
Cumulative Count Difference (加总流量差)

15:19:03
Queue arrival at detector 60

Time
0 13:00 14:00 15:00 16:00 17:00 18:00 19:00

Oblique cumulative $N(70,t) - N(60,t)$

$N(t)$
Count Variance (流量波动)

![Graph showing variance over time.]

- Time: 13:00 to 19:00
- Y-axis: Variance of prior two minute counts
- X-axis: Time
- 15:05:23
- 15:19:03 Queue arrival at detector 60
- 15:16:23

Legend:
- Black line: Variance
- Green bars: Oblique cumulative variance
Oblique Velocity

15:18:03 Median Lane
15:18:23 Shoulder Lane
15:18:23 Center Lane

V(x,t) = v_0 t', v_0 = 39 kilometers/hour

Speeds in miles/hour

Time, t

15:00:03 15:05:03 15:10:03 15:15:03 15:20:03 15:25:03 15:30:03 15:35:03

55 46 45 51 52 39 35 33 30 31 27 25 24
Oblique Cumulative Occupancy (加总密度)

15:19:03 Queue arrival at detector 60

T(60, t)

T(70, t)

15:19:03

13:00 14:00 15:00 16:00 17:00 18:00 19:00
Time

Oblique T(x, t)

b)

Oblique T(60, t) - T(70, t)
Conclusions

- Possible to diagnose bottleneck location and activation/deactivation times
- Reproducible high flow signal
- Other signals demonstrated
- Systematic approach needed
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More information (更多信息)

- Email: bertini@pdx.edu
- Web: http://www.its.pdx.edu
- Bottleneck data readily available.