A study of the opening size of auxiliary lanes on the driving behavior-based analysis

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Introduction
What is auxiliary lane?

lower-grade highway (lower speed)
for the vehicles to enter and exit the high-grade roads
for the vehicles not permitted into the high-grade roads
an important means of access management control
Forms of auxiliary lane

**Integral auxiliary lane**

**Segregated auxiliary lane**

Function of auxiliary lane

Speed transition:

to transversely isolate the fast traffic flow from the slow traffic flow in space
The opening area

Where vehicles enter and exit the main lane
Where vehicles’ speed changes
Where traffic danger conceals

Problem we face

What is the best length?
Analysis on Driving Behavior

Phases of driving behavior

- Environment information
- Information perception
- Decision making
- Vehicle handling
- Vehicle moving status

Feedback
Stages of lane changing

1. Decelerating stage
2. Turning stage

Notice the opening location
Stomp the brake pedal
Adjust the vehicle speed

Notice the opening size (angle)
Turn the steering wheel
Change the lane
Lane changing behavior

Terms of Assumption
Model specification

Terms of Assumption

1) The lateral motion does not affect the longitudinal motion
2) The process of lane changing has geometric center symmetry
Jose L Bascunana (1995)

The Vertical Deviation Angles $\alpha_1$ & $\alpha_2$ are quiet small

In longitudinal motion

Longitudinal velocity $V_{x1} = V_{x2} = V_0$

(1) $S_{x1} = V_{x1}t_1$, $S_{x2} = V_{x2}t_2$
In lateral motion

Vehicle speeds up at first and then slow down
Lateral velocity changes from 0 to Max, then to 0 again
The acceleration process is short to be two uniformly accelerated motions

\[(2) S_{y1} = 0.5 a_1 t_1^2 , S_{y2} = 0.5 a_2 t_2^2 \]

Constraints of lateral movement

\[(3) S_{y1} + S_{y2} \geq W_l \]

where \(W_l\) stands for one lane’s width
Center symmetry

(4) $a_1 = a_2 = a$

(5) $t_1 = t_2 = t$

Constraints of longitudinal movement

(6) $S_{x1} + S_{x2} \leq OS$

where OS stands for opening size
We can get

\[(7) \text{OS} \geq 2 V_0 \sqrt{W_i / \alpha}\]

Minimum Opening Safe Spacing
Definition

MOSS = 2V₀√W₁/𝑎

where MOSS stands for Minimum Opening Safe Space

Guideline to design

The design velocity of auxiliary lane is 30~40 km/h
So V₀ ranges 20~50 km/h for |ΔV|≤20km/h

According to
- Specification for Design of Urban Expressway
- Code for design of urban road engineering
- Design Specification for Highway Alignment

The width of lane W₁ = 3.75m
The acceleration a = 0.1g for stability and comfortableness

The value table of MOSS

<table>
<thead>
<tr>
<th>Velocity (km/h)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
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<tbody>
<tr>
<td>Calculated Value (m)</td>
<td>21.7</td>
<td>32.60</td>
<td>43.47</td>
<td>54.34</td>
</tr>
<tr>
<td>Recommended Value (m)</td>
<td>25</td>
<td>35</td>
<td>45</td>
<td>55</td>
</tr>
</tbody>
</table>
Simulation Test & Results

Preparation

Programming: UC win / road

Scene: 1 km 2-lane highway with auxiliary lane, which opens at 700m

Volunteer: 30 with ten-year driving experience
20 unskilled

Parameter: v=40 km/h  os= 45m

Test: mean lateral acceleration
Data

Normal Probability Plot

Results

1. Normality of the test data demonstrate that the model conforms to driver’s driving habits.

2. Lower acceleration, easier to control the vehicle, as the unskilled does.

3. More people would like to drive in a high speed, then hasty handling happens when they change lane from the main to the auxiliary.
Further study

1. Whether vehicles' size affects the design of the auxiliary lane opening

2. Whether different lighting conditions affects the variation of vehicle moving status in the opening area

Thank you