ACC impacts on sag sections under mixed traffic environments

混在交通下のサグ区間におけるACCの影響

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1. Background and object

In recent years, many cars have been equipped with Adaptive Cruise Control (ACC), and its use is increasing.In recent future vehicles with and without ACC are mixed on freeway is expected.

This research is aiming at Evaluation of the impacts of ACC under the mixed traffic on sag sections.

2. Methodology

- Flow of this research is like below:

I Modelling of vehicles **without** ACC by citing existing researches

II Modelling of vehicles **with** ACC by existing model, estimate parameters based on empirical data

III Analysis of sensitivity of ACC penetration rate by the model above and considering sag influence

3. Modelling

I Modelling of vehicles without ACC

- For vehicles **without** ACC, General Motor (GM) model including **vehicle acceleration, difference in velocity and distance between 2 vehicles**, is used.

II Modelling of vehicles with ACC

- For vehicles **with** ACC. Non-linear state-feedback control model is used. In this model, **acceleration, position, velocity, desired time gap, and gained errors of position and speed** of leading and following vehicles are included.
- For **Sag** influence:
  - **Non-ACC** vehicles will gradually be aware of gradients changing and consciously accelerate to adapt. **Extra Linear changing model** of awareness time β is introduced.

$$\beta(t) = 1, t > T_1$$

$$\beta(t) = 1 - \frac{t - T_1}{T_2 - T_1}, T_1 \le t < T_2$$

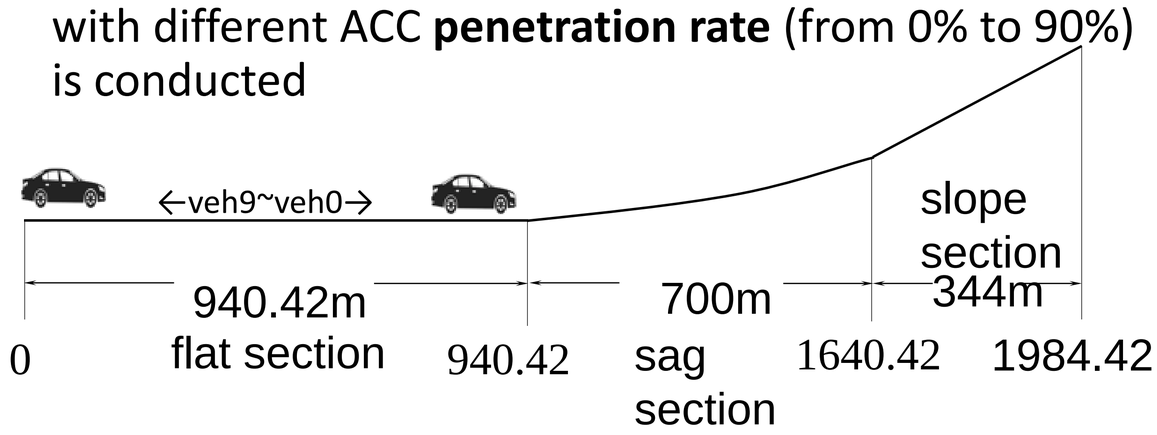
$$\beta(t) = 0, \mathrm{t} \ge T_2$$

  - $T_1 = 3.7s$ is the start time of gradient change adaptation and T_2=10.6s is the end time of gradient change adaptation
  - **ACC** vehicles are relatively inflexible to be aware of gradient changes, $\beta = 1$ is used to describe it.

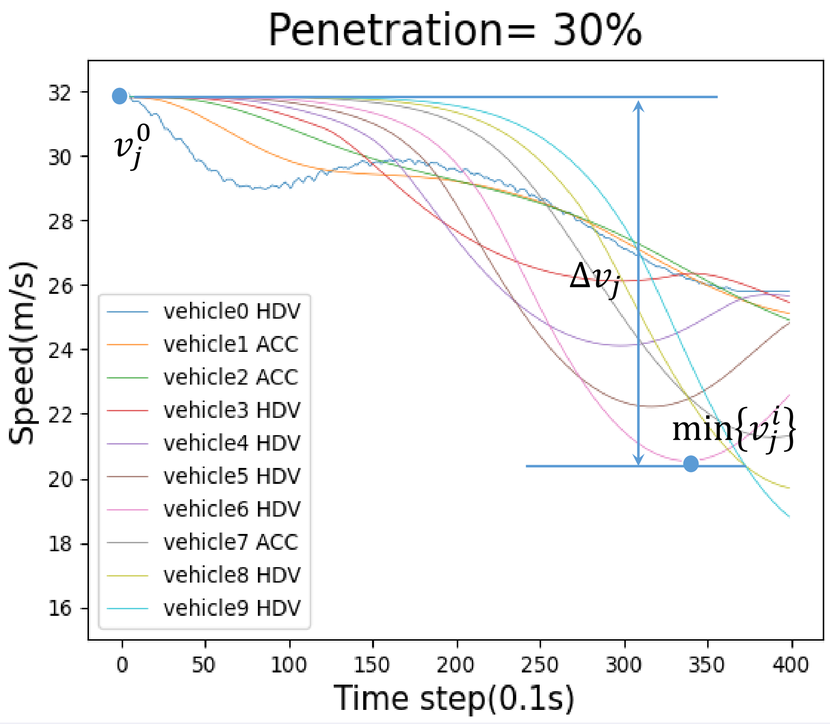
4. Simulation

III Analysis of sensitivity of ACC penetration rate

- Sensitivity analysis in the sags section:
  - Traffic simulation of **10 vehicles** (numbered veh0~9) with different ACC **penetration rate** (from 0% to 90%) is conducted



- **Range of speed variation** $R_{\Delta v} = \max\{\Delta v_j\} - \min\{\Delta v_k\}$ is used to evaluate **stability of the queue**, *j, k* represent different vehicles.
  - $\Delta v_j = v_j^0 - \min\{v_j^i\}$, v_j^i is for the speed of vehicle *j* at time *i* , following graph shows the definition of Δv_j



5. Result and conclusion

- Result of $R_{\Delta v}$ under different ACC penetration rate shows in the following graph. It represent a conclusion that while **penetration rate reaches 70%,** queue of 10 vehicles go to the **most stable** status.