Compatibility Checking for Autonomous Lane-Changing Assistance Systems

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BACKGROUND & MOTIVATION

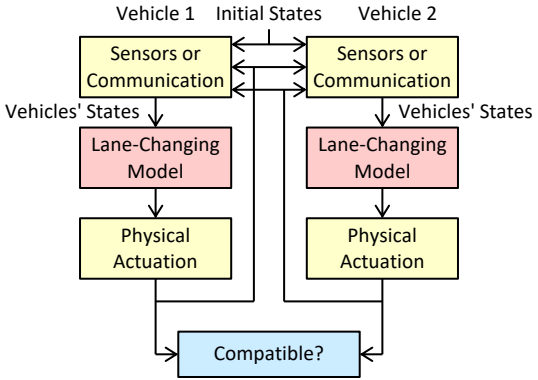
- An **incompatible** scenario of lane changing
  - Two vehicles always accelerate or decelerate together
  - They always keep the same longitude along a road segment
  - They fail to exchange their lanes before the end of the road segment
- Challenges
  - Different automotive makers/suppliers) develop different types of systems by their own
  - A compatibility issue may be resolvable by human drivers, but not by autonomous vehicles

NEW INSIGHTS

- A methodology and an algorithm to verify if two lane-changing models are compatible
  - Compatible := two vehicles exchange their lanes before the end of the road segment (liveness)
- Design-time usage (if incompatible)
  - Trigger redesign of lane-changing models
- Runtime usage (if incompatible)
  - Prevent incompatible vehicles from entering the road segment with the incompatible conditions (by traffic lights or instruction messages)

DESCRIPTION

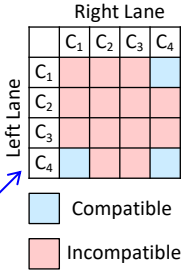
- Methodology



- State of a vehicle = (v, x, l)
  - v: the velocity
  - x: the longitude along the road segment
  - l: the lane that the vehicle is on
- Algorithm
  - The states and the time steps are discrete as the control command is discrete and periodic
  - The initial states are defined by ranges to provide flexible granularity for incompatible conditions
  - The state traversing is based on a depth-first search

QUANTITATIVE IMPACT

- Four lane-changing models
  - C_1 [Wang, ICCC'17]
  - C_2 [Ouyang, CAC'20]
  - C_3 [Zheng, T-ITS'20]
  - C_4: a priority-based controller
- Compatibility with ±5m/s initial velocities, ±5m initial longitudes, and 200m road segment
- Higher incompatible probabilities
  - Larger initial ranges
  - Shorter road segments



SUMMARY AND CONCLUSION

- We verify if two lane-changing models are compatible
  - The verification results can be utilized during runtime to prevent incompatible vehicles from entering a lane-changing road segment
  - To the best of our knowledge, this is the first work targeting the compatibility for lane-changing models
- Future directions
  - Compatibility checking for hybrid systems
  - Lane-changing scenarios with more vehicles
  - More complicated applications such as intersection management