A Collision Avoidance System with Fuzzy Danger Level Detection

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Introduction

- Traffic accidents cause about 37,000 fatalities and over 230 billion dollars in economic loss every year
- 75% of accidents happen during lane changes
- Advance Driver assistance Systems (ADAS) have the potential to reduce the risk of accidents as the system will take over control of the vehicle in dangerous scenarios and prevent potential crashes
- Detecting dangerous lane change events and modifying them to avoid accidents is essential in increasing traffic safety

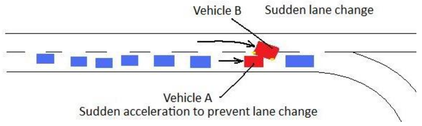

Figure 1: Example of an accident in lane change scenario

Challenges

- Clean and pre-process the naturalistic driving data which contains over 50,000 observations of lane-change events
- Transform the large-scaled raw data to useful, organized information
- Develop a model to capture the real life factors which have the potential to cause the accidents while changing the lane
- Design the control system to react according to the risk estimation result, in order to decrease the level of danger

Proposed Solution

- **Scenario**: Lane-change maneuver
- **Risk Assessment**: Estimate the risk of ego vehicles and surrounding vehicles that provide a reasonable danger-level estimation
- **Collision Avoidance**: Implement the model to adjusting the driving behavior to avoid potential collision and reduce risk of current driving behavior

Methodology

Fuzzy Danger Level Detection

- ***Estimate on Subject vehicle***
  - ***Inputs:*** Velocity, Yaw-rate, Accelerations in Longitudinal & Lateral
  - Model based on Mamdani's fuzzy inference method
  - ***Output*:** Danger-level percentages
- ***Estimate on Surrounding vehicle***
  - ***Inputs*:** Relative velocity of surrounding vehicle, relative distance in longitudinal & lateral
  - Model Based on Mamdani's fuzzy inference method
  - ***Output*:** Danger-level percentages

Collision Avoidance System

- Model predictive control(MPC)
- Trajectory planning
  - Optimize the accelerations in longitudinal
  - Optimize the distance in lateral
  - Danger level affect on safe sap constrain

Fault Determination Classifier

- Extreme Gradient Boosting trained with naturalistic driving data

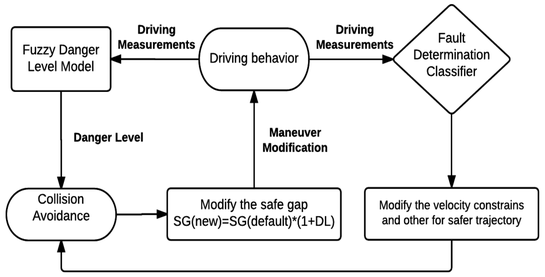

Figure 2: Schematic diagram of the proposed system

Simulation and Results

Example Lane-change Driving Scenario:

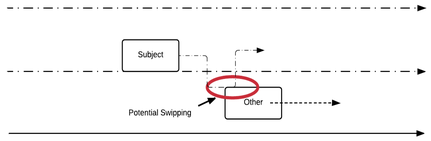

Figure3: Example of a near crash event

- Figure 3 is one near-crash event from dataset as subject vehicle trying to execute lane-change to adjacent lane, but become too close to other vehicle and have to turn back to prevent the accident
- Figures 4-7 present the longitudinal and lateral trajectory planning of an event before and after the system is activated
- The proposed system can detect that maneuver with highest 75% danger level and the fault is most likely to be subject vehicle, the trajectory will be modified accordingly

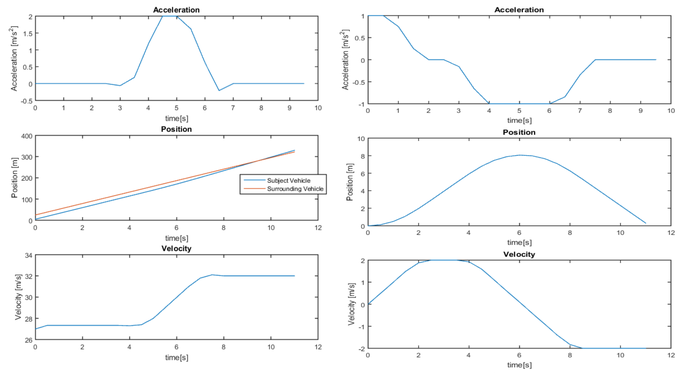

Figure 4, 5: Longitudinal trajectory, Lateral trajectory of a near crash event

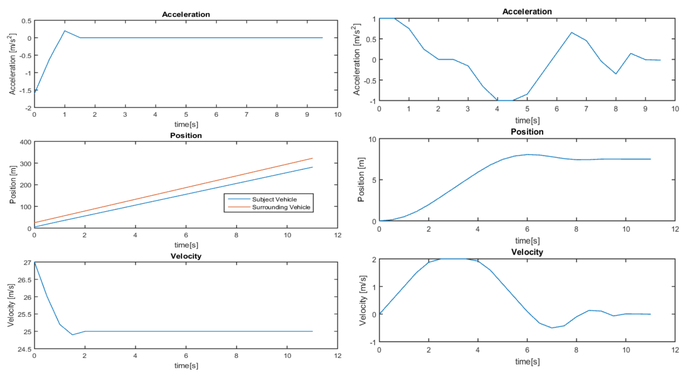

Figure 6, 7: Longitudinal trajectory , Lateral trajectory of the modified crash event

Conclusion/ Future Work

Significance

- ✓ Estimate the driving behavior
  - Ability to evaluate the driving behavior of subject vehicle and provide a reasonable estimation of the danger of the maneuver
- ✓ Prevent/decrease the potential danger
  - Ability to plan the trajectory according to the percentage of the danger-level to ensure the safety of the subject vehicle

Future Work

- Developing a risk assessment that considers the interactions between road users and intention of surrounding vehicles to help the lane-change execution more smooth and efficient

Target Market

- Vehicle manufacturers developing advance driving assistance system
- Insurance companies who wish to monitor the abnormal behavior of customers' vehicle

Relevance

- ADAS is a popular technic in the Automotive industry
- Situation Assessment & Collision Avoidance is a essential part for ADAS
- Naturalistic driving data analyze method could applied in similar dataset such as: UAV datasets

References

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