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# Learning from human driving data for risk assessment in lane change

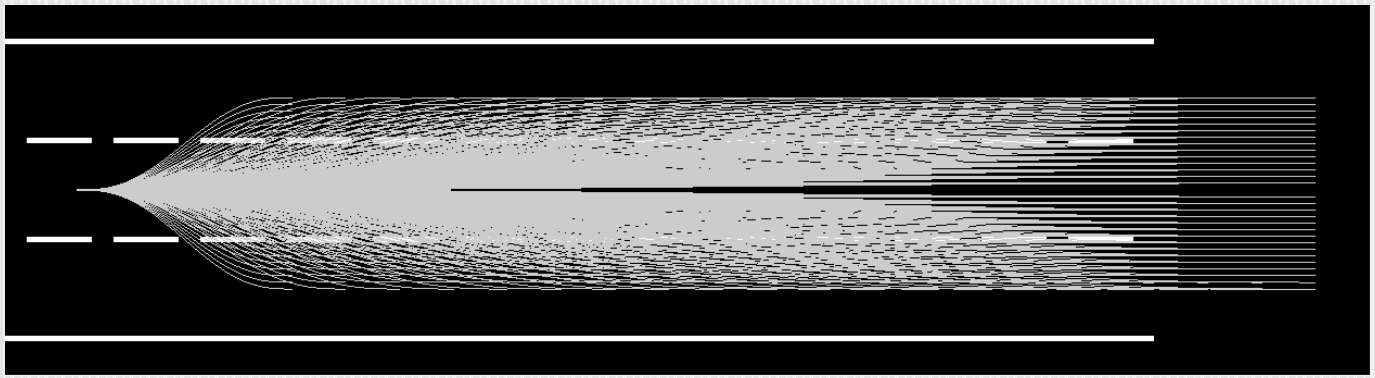
# Motivation

- What kind of scenario
  - Urban highway scenario with fluent but heavy traffic at high design speed

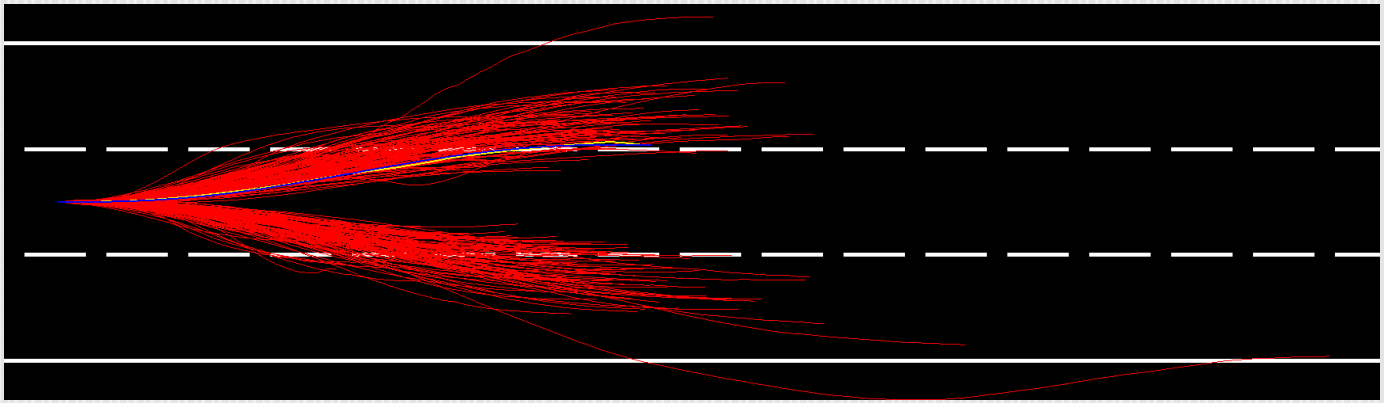
- Why study lane change behavior
  - One  of most common and important daily driving behavior
  - Longitudinal movement: well studied (e.g. Adaptive Cruise Control) ;
    **lateral movement**: more complicated with change of path shape (with additional operation on steering)
  - Application
    - **Lane change prediction for more accurate risk assessment**

# Motivation

- Why learn from real human driving data
  - **To Better predict the risk in lane change behavior (our current objective)**



Parametric Lane Change Trajectories

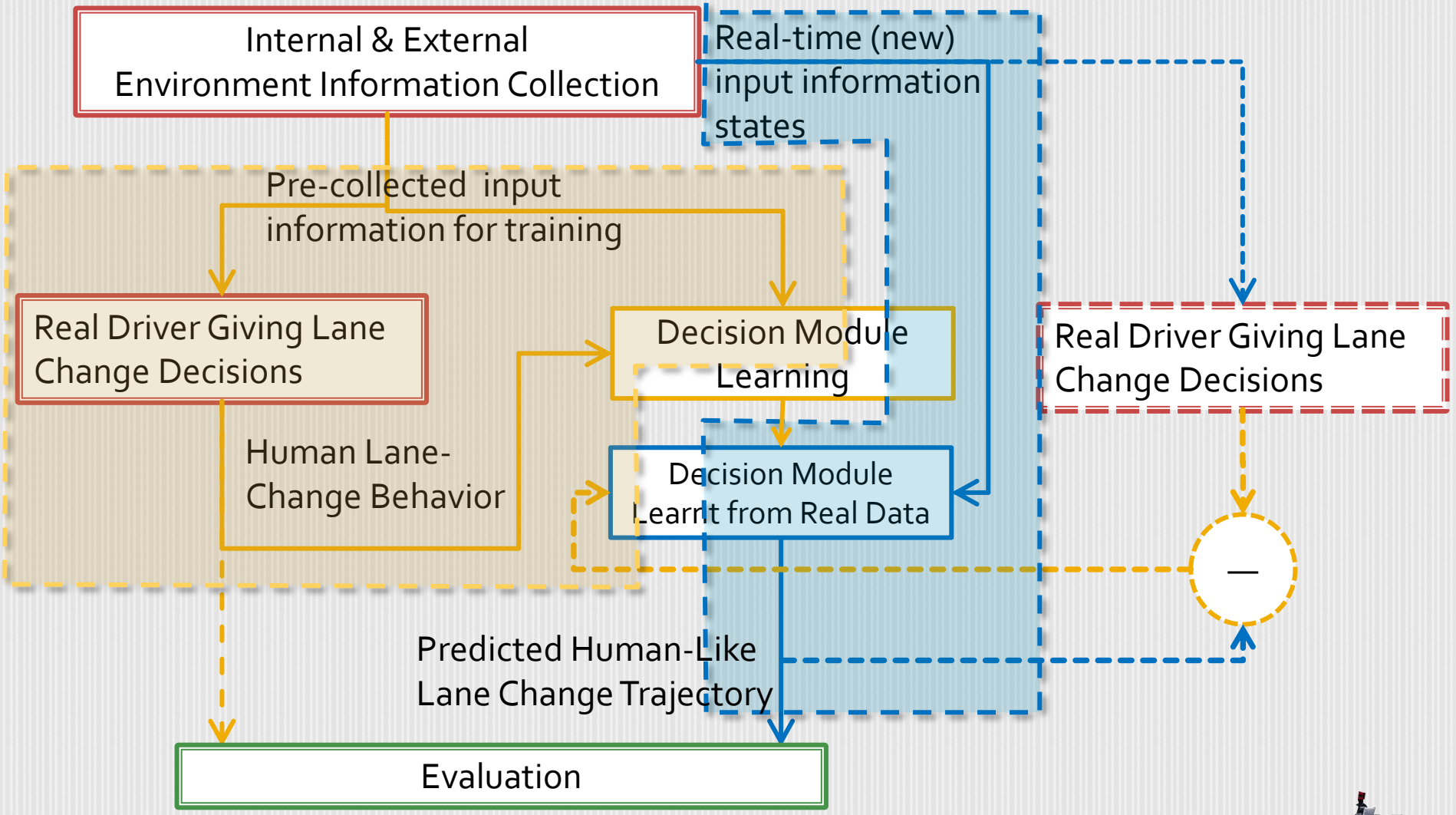


Real Human Lane Change Trajectories

# Objective

- To learn to predict lane change risk from real human driving data at the beginning of a lane change behavior
  - To easily acquire **real driving data** in urban driving scenario
    - Efficient data collection system
  - To model the characteristic of personal lane change
    - What kind of lane change risk assessment is considered to be suitable for the (or this) driver
  - To design a prediction module to produce personal lane change prediction

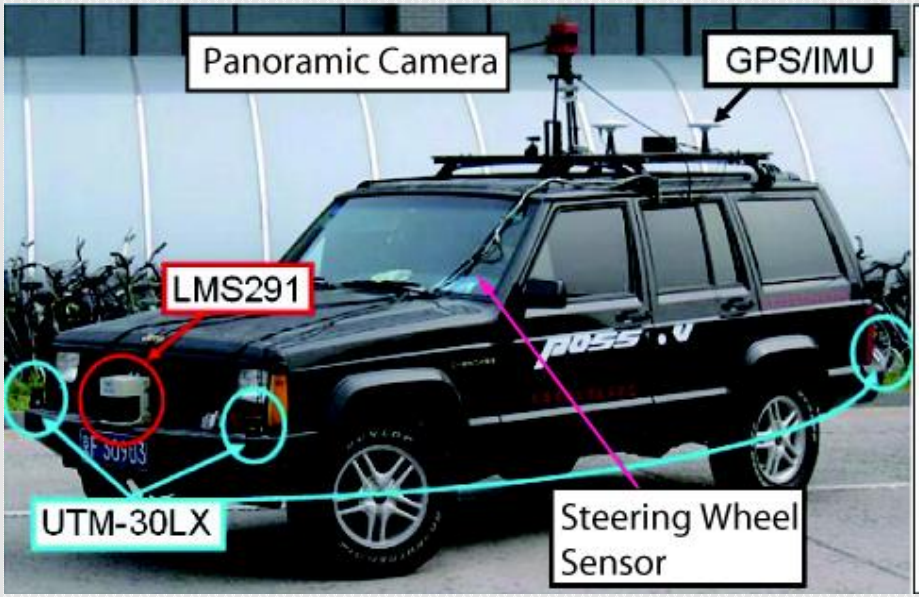
# Framework

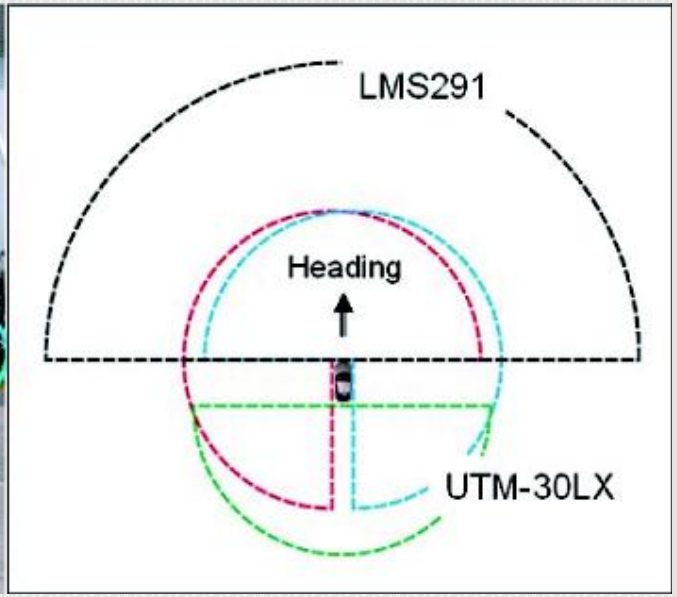

Internal & External Environment Information Collection
Real-time (new) input information states
Pre-collected input information for training
Real Driver Giving Lane Change Decisions
Decision Module Learning
Real Driver Giving Lane Change Decisions
Human Lane-Change Behavior
Decision Module Learnt from Real Data
—
Predicted Human-Like Lane Change Trajectory
Evaluation

# Implementation & Experiments

- Platform and experiment setting
- Work flow
- Human lane change data collection
- Experiment results

# Data Collection Platform

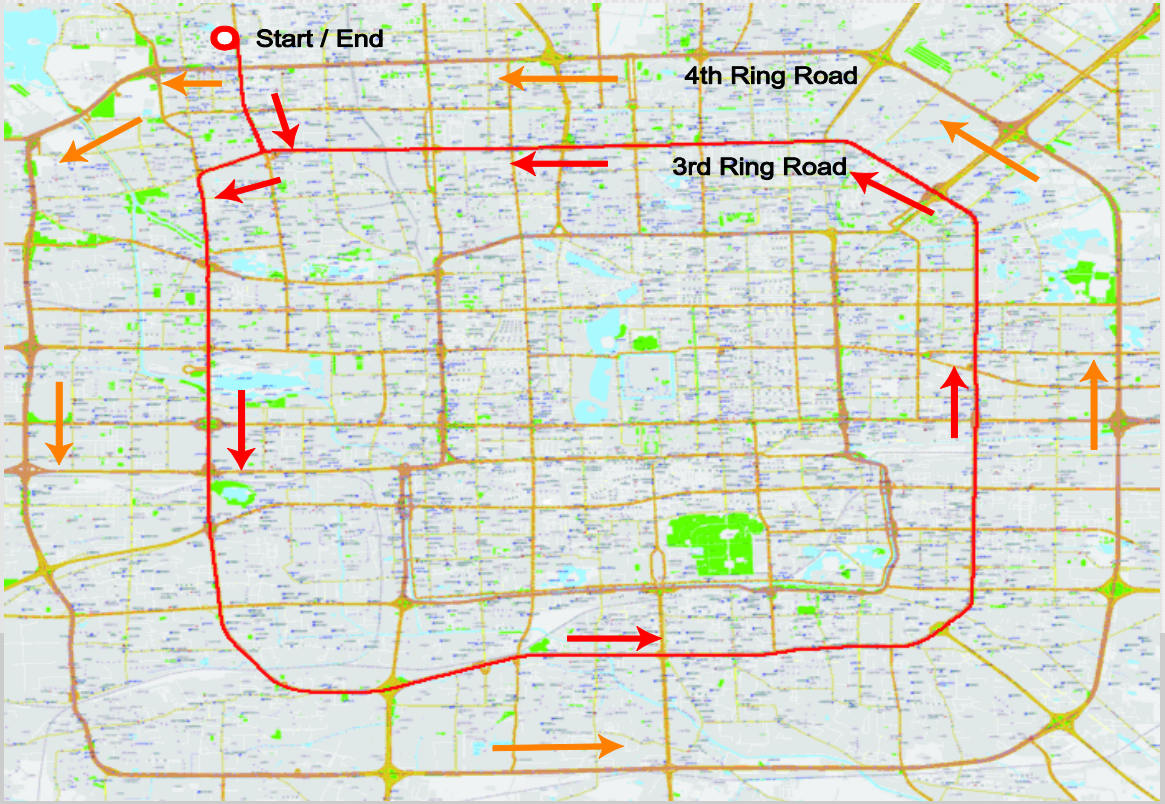



- Key sensors :
  - Omni direction laser sensor layer
  - GPS
- Assistant sensors:
  - Panoramic Camera
  - Steering Wheel Sensor

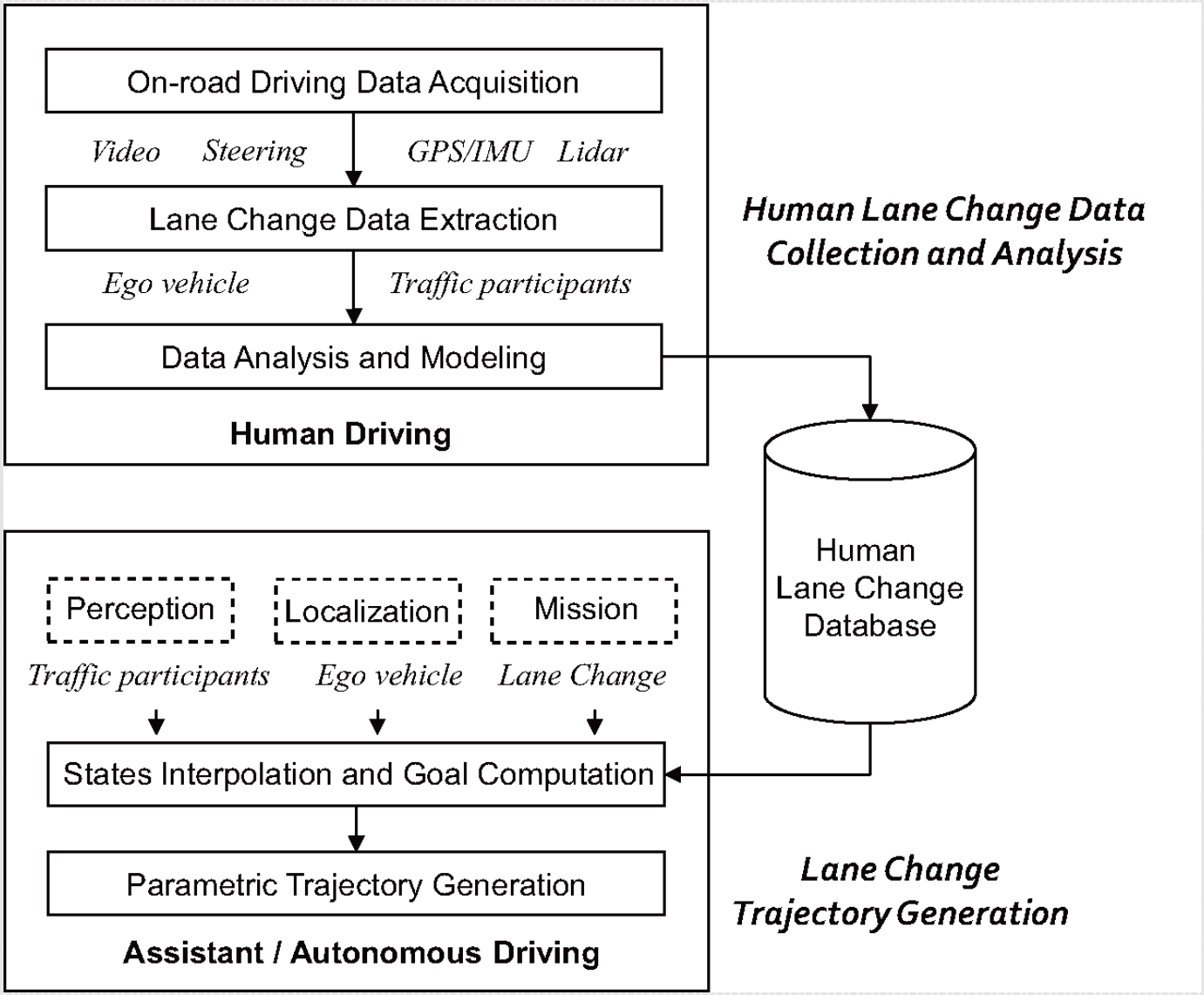
# Human Lane Change Data Collection

- Experiment setting
  - Peking's 4th Ringroad
  - Highway scenario
  - Heavy but fluent traffic



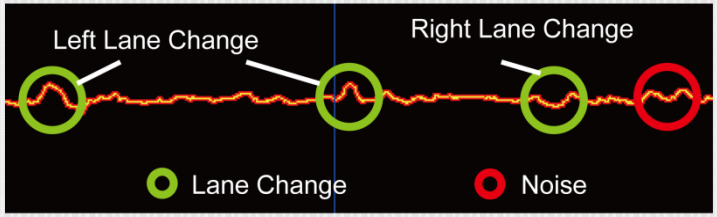

| | Ring Road 3 | Ring Road 4 |
|---|---|---|
| Distance(km) | 48.3 | 85.3 |
| Design Speed(km/h) | 80 | 80 |
| Experiment Rounds | 1 | 6 |
| Lane Change Trajectories | 27 | 474 |
| Drivers | 1 | 5 |

# Work Flow

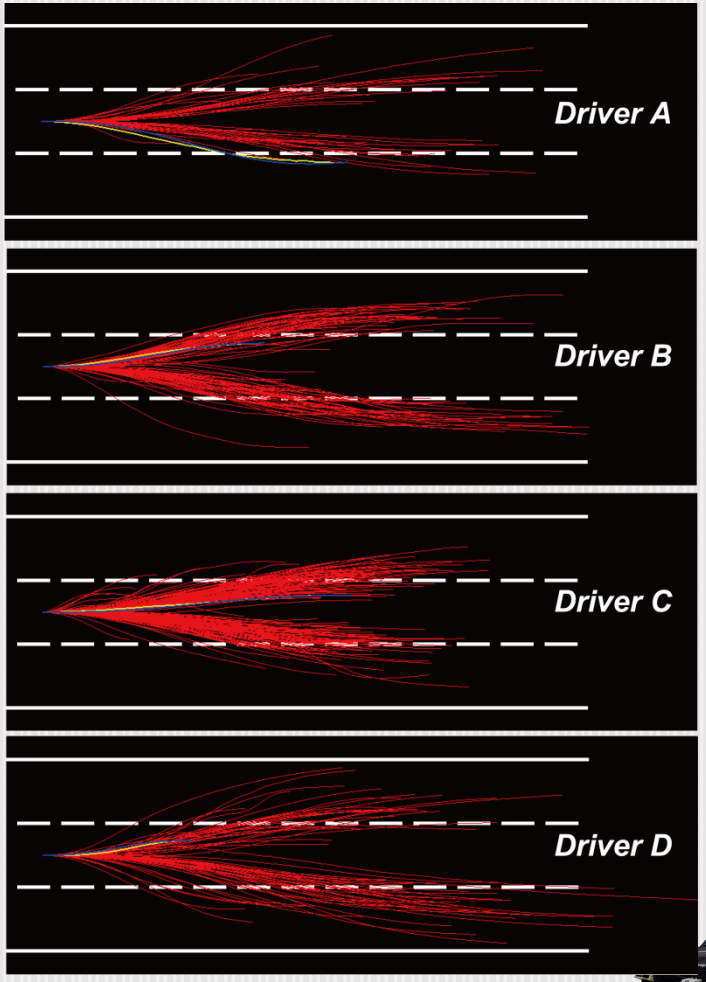

On-road Driving Data Acquisition
Video
Steering
GPS/IMU
Lidar
Lane Change Data Extraction
Ego vehicle
Traffic participants
Data Analysis and Modeling
Human Driving
Human Lane Change Data Collection and Analysis
Human Lane Change Database
Perception
Localization
Mission
Traffic participants
Ego vehicle
Lane Change
States Interpolation and Goal Computation
Parametric Trajectory Generation
Assistant / Autonomous Driving
Lane Change Trajectory Generation

# Human Lane Change Data Collection

- Segment lane change trajectory from GPS position
  - Manually recorded lane change start/end time
  - Steering wheel data

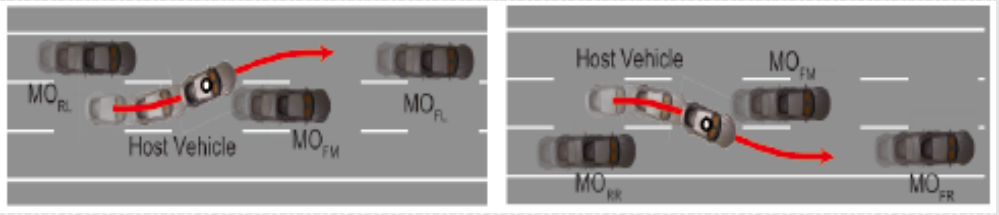


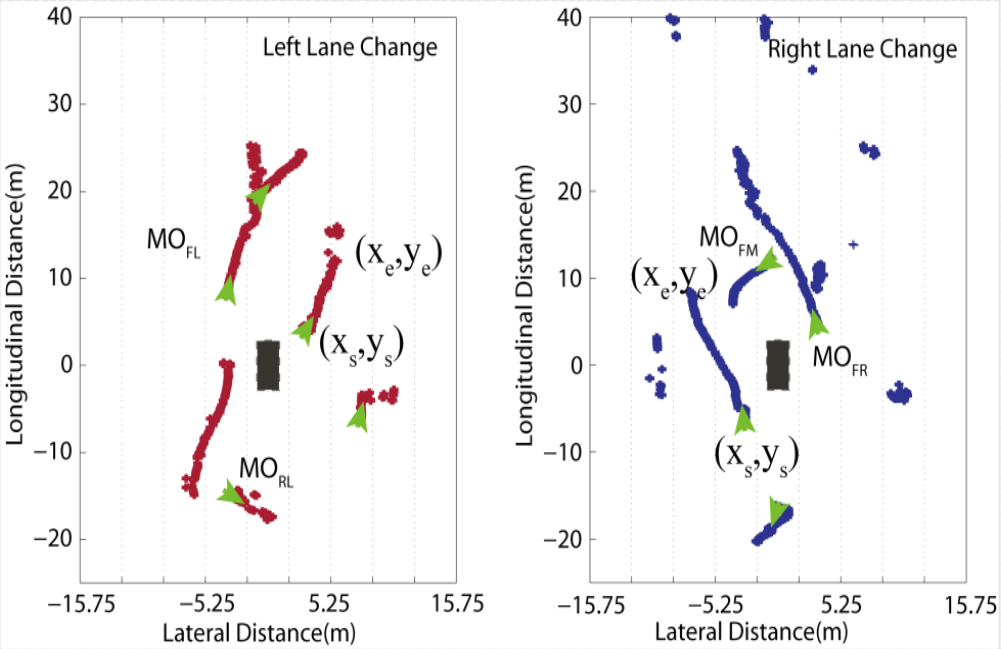

  - Video check

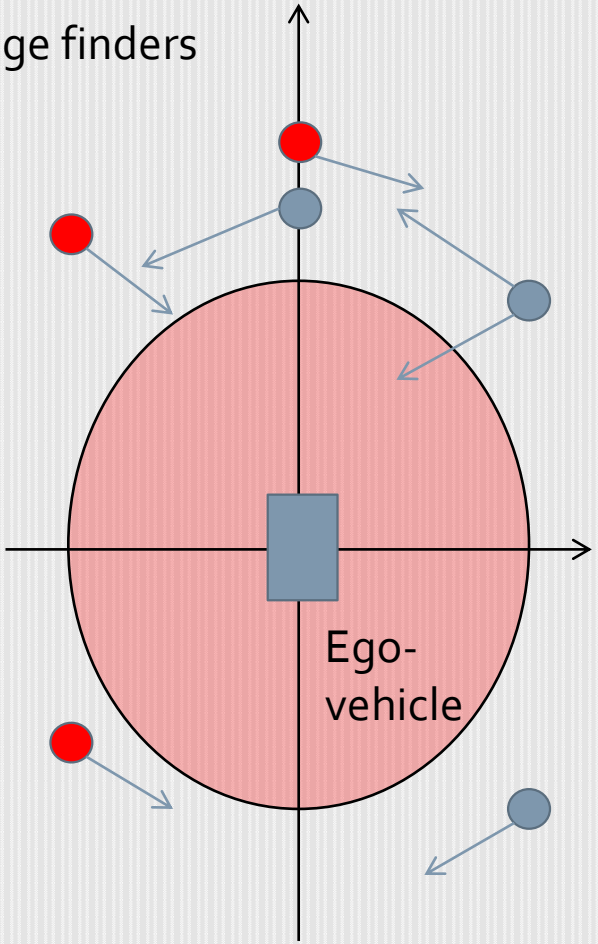


# Human Lane Change Data Collection

- Traffic participants around the ego-vehicle
  - Moving object detection and tracking using laser range finders

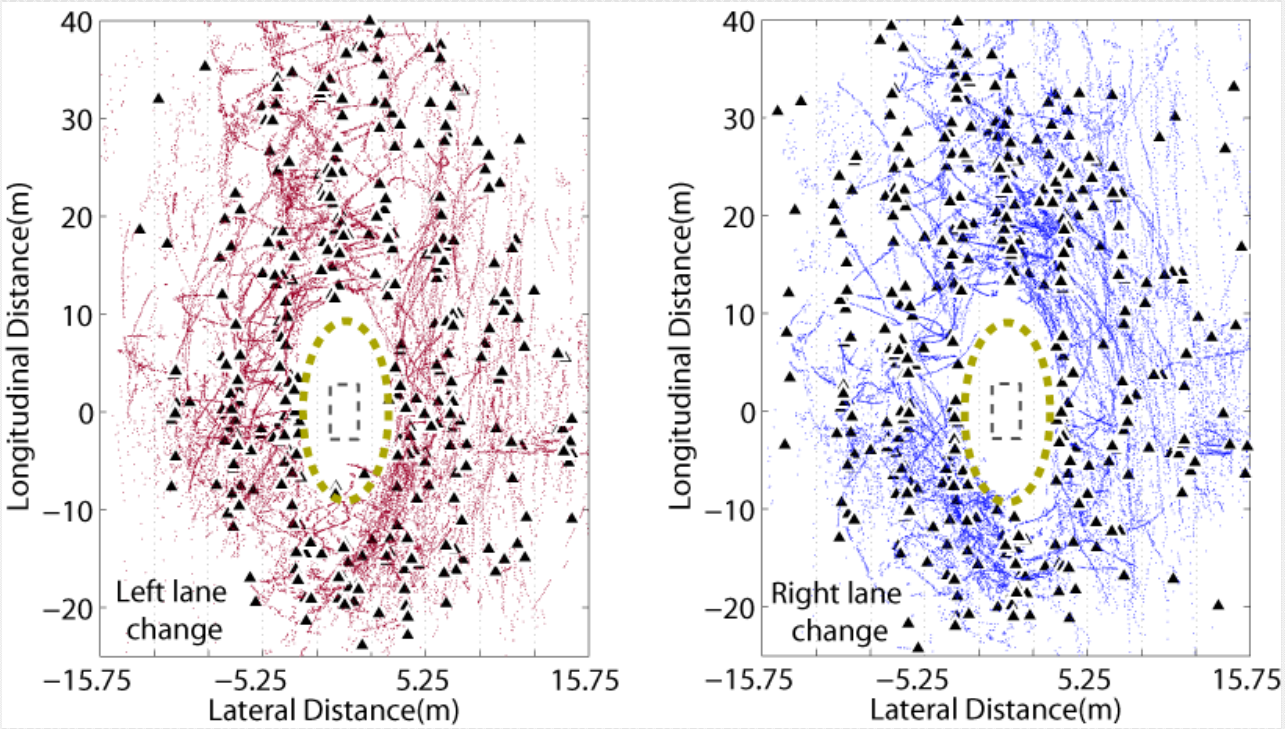


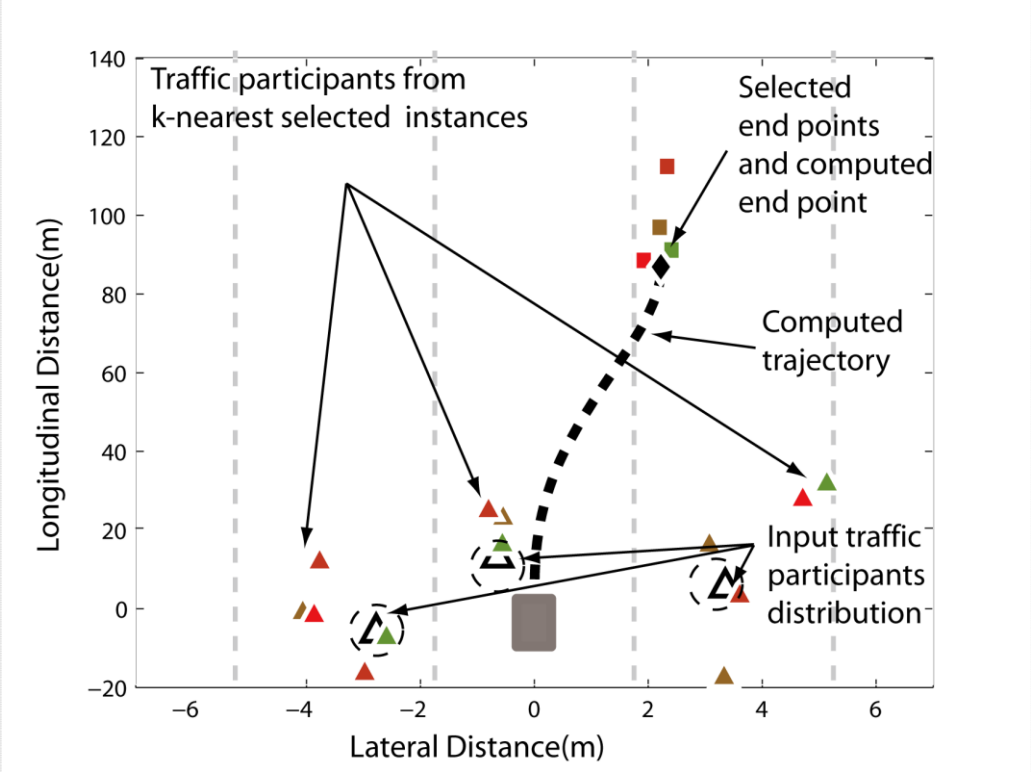

# Human Lane Change Data Collection

- Traffic participants around ego-vehicle
  - Safety zone
  - Driver / driving condition specified




# Trajectory Prediction

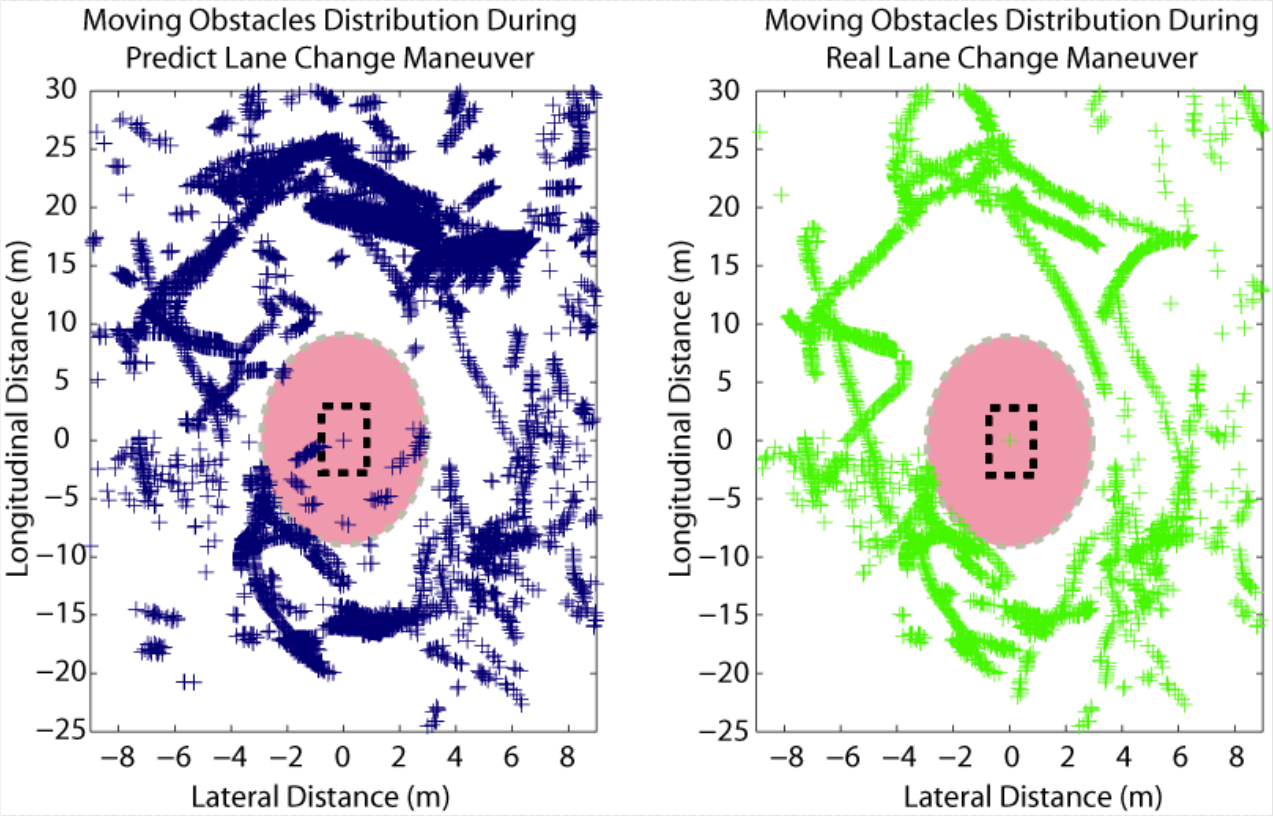
- Input:
  - Traffic participants states
    - Position…
  - Ego-vehicle state
    - Speed, position….
- Output:
  - Search for K- nearest cases
    - States Distance measure:
      - $S = (x_{fl},\ y_{fl},\ x_{fm},\ y_{fm},\ x_{fr},\ y_{fr},$
      - $x_{rl},\ y_{rl},\ x_{rr},\ y_{rr},\ C \cdot v_H \ldots)$
      - Euclidian distance: $d_{12} = \|S_1 - S_2\|^2$
  - Lane change end point
    - Inverse distance weight
  - Path: quintic polynomial curve in Frenet Frame
  - Speed profile



# Trajectory Prediction Results

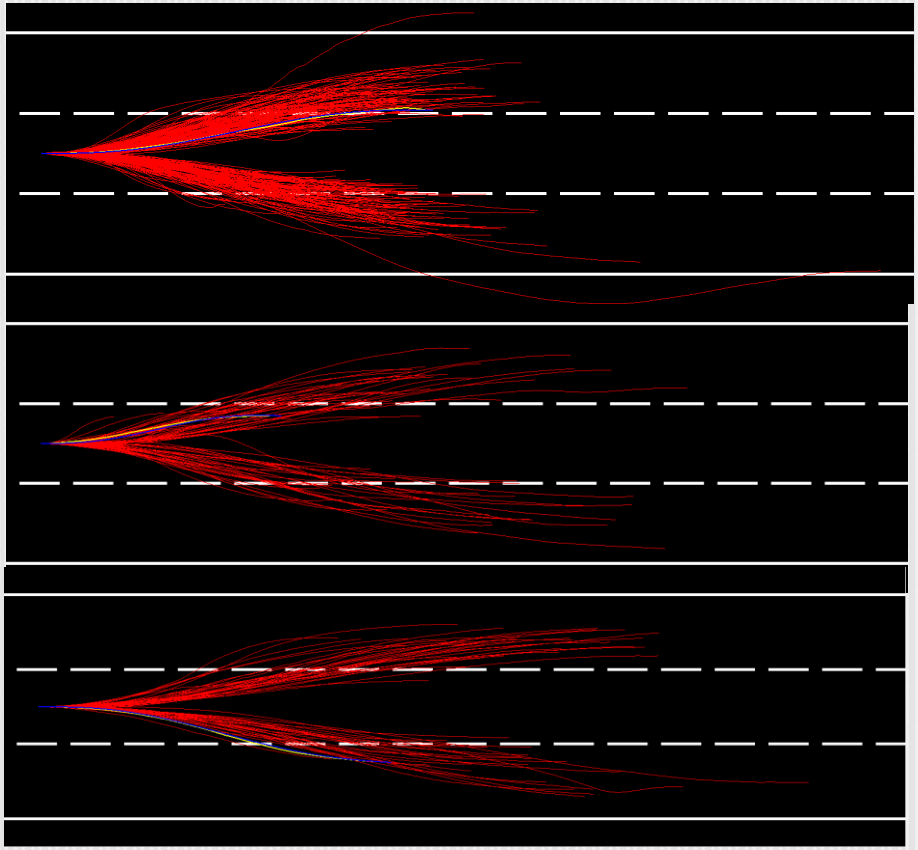
- Result

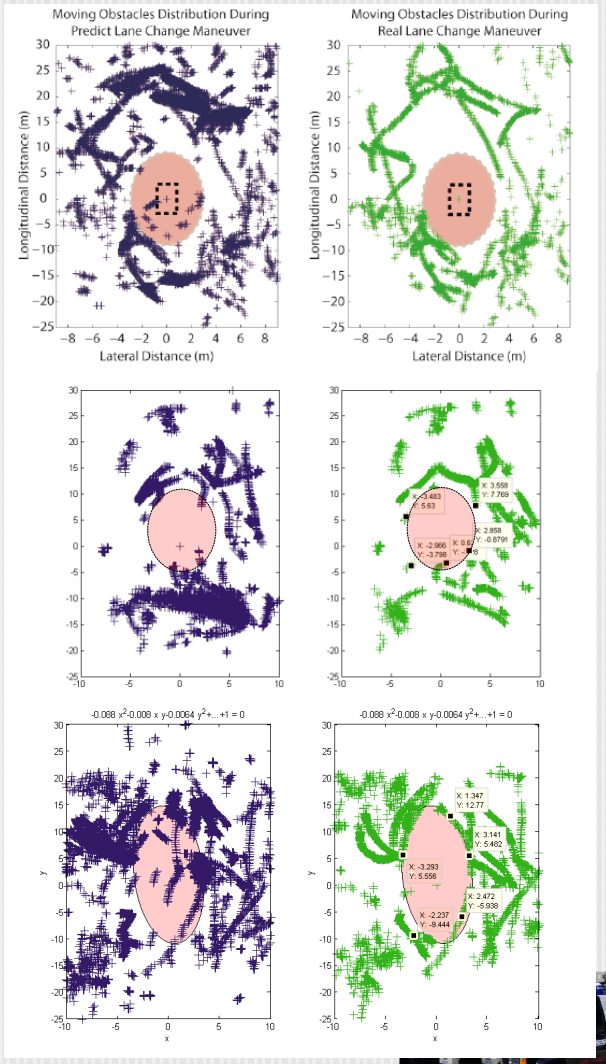
- Traffic participants distribution resulted from prediction vs. real trajectory



# Future Work

- Comparing between different drivers' lane change lane change behaviors to give driver adapted lane change risk assessment.





# Thank you