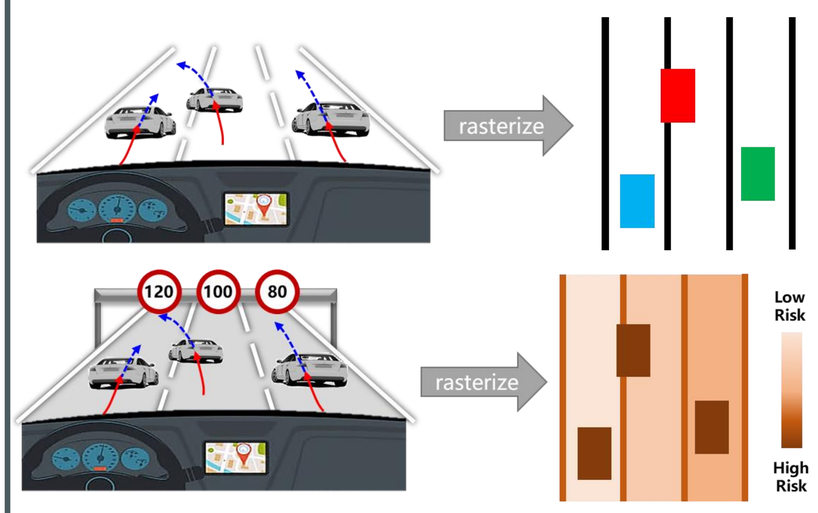
Trajectory Prediction of Surrounding Vehicles based on Traffic Scenario Understanding

Introduction

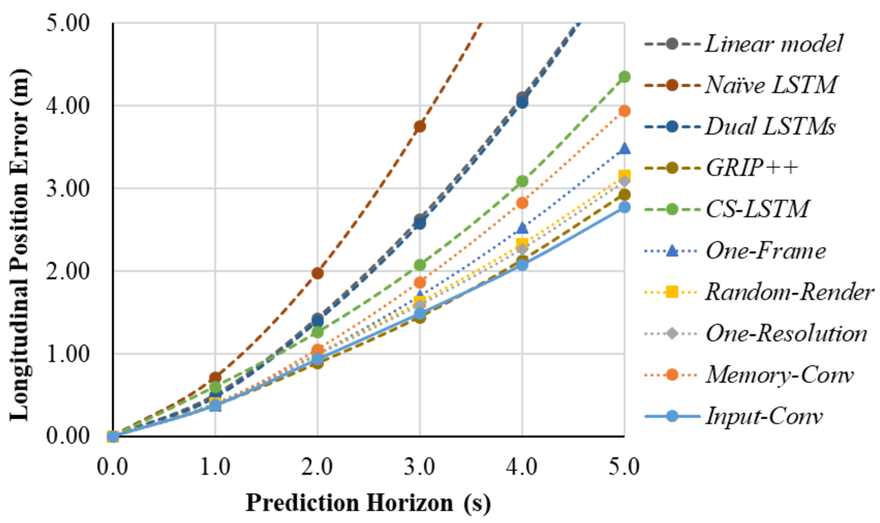
Accurate and fast trajectory prediction of surrounding road users is critical to improve the intelligence of autonomous driving systems. In complex traffic scenario, road users with different kinds of behaviors and styles and road with different kinds of areas and markers brings complexity to the environment, which requires considering interactions among road users and road structure and traffic rules, when anticipating their future trajectories. This study proposes a long-term parallel interactive trajectory prediction method based on scenario understanding.

Graphical Scenario Representation in Risk-Based Rank

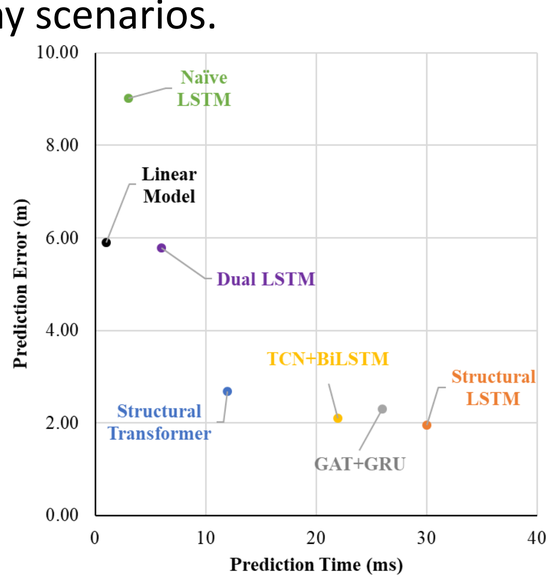
Varying numbers and types of vehicles, various road structures and traffic rules bring difficulties to an autonomous vehicle driving in highway traffic scenarios. It is important to simultaneously consider all these elements in an integrated framework when predicting the future trajectories of surrounding vehicles. This research presents a unified graphical representation method for dynamic traffic scenarios based on integrating not only the constraints from vehicles but also the collision risk implied behind road structures and traffic rules. Different from previous studies which ignores road structures and traffic rules or separately represent them in a qualitative way, this method can make better use of the influences of these environment elements in a quantitative way to improve trajectory prediction of surrounding vehicles in highway scenarios.



Qualitative and Quantitative Graphical Representation Methods



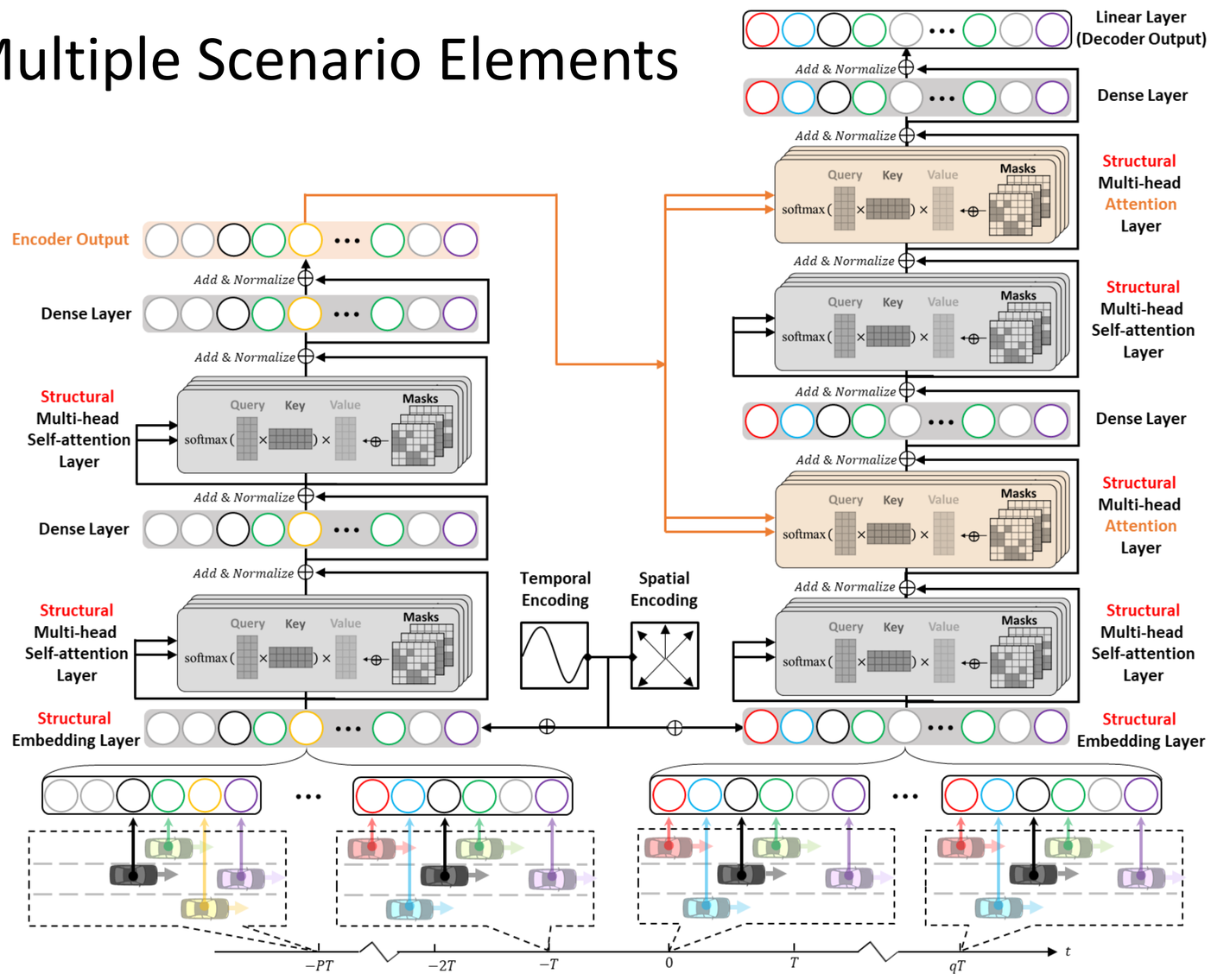
Prediction Error at Different Horizon



Prediction Speed-Accuracy Trade-off

Parallel Interaction Model for Multiple Scenario Elements

Fast and accurate long-term trajectory prediction of surrounding vehicles (SVs) is critical to autonomous driving systems. In high-density traffic flows, strongly correlated vehicle behaviors require considering the interactions among multiple SVs when predicting their future trajectories. However, existing interactive prediction methods, most based on Long Short-Term Memory (LSTM), are suffering from slow prediction because they analyze SVs one by one and analyze trajectory sequence node by node. This research presents a fast interactive trajectory prediction method called Structural Transformer which learns both spatial and temporal dependencies among multiple SVs in parallel. The computational time of each step is only 12ms on a 2080ti GPU, which is over 4 times faster than the non-parallel model like Structural LSTM.



Structural Transformer Architecture

Publications

L. Hou, S. E. Li, B. Yang, Z. Wang and K. Nakano, "Integrated Graphical Representation of Highway Scenarios to Improve Trajectory Prediction of Surrounding Vehicles," in IEEE Transactions on Intelligent Vehicles, vol. 8, no. 2, pp. 1638-1651, Feb. 2023, doi: 10.1109/TIV.2022.3197179.

L. Hou, S. E. Li, B. Yang, Z. Wang and K. Nakano, "Structural Transformer Improves Speed-Accuracy Trade-Off in Interactive Trajectory Prediction of Multiple Surrounding Vehicles," in IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 12, pp. 24778-24790, Dec. 2022, doi: 10.1109/TITS.2022.3193665.