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Vehicle Location and Trajectory Prediction Based on the Fusion of Beidou Navigation System and AI Vision

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Autonomous driving relies on centimeter-level positioning and accurate trajectory prediction for safety, yet faces many challenges .Our unified framework addresses these issues through three innovations: 1) Dynamic lateral error correction via V2X communication; 2) STGCN based traffic behavior interpretation; 3) Diffusion model-enabled multi-trajectory generation. A joint optimization mechanism balances localization and prediction modules, compensating for IMU drift while maintaining motion consistency[3]. The system fuses BeiDou's absolute geolocation, camera-based object detection, and IMU data through a collaborative filtering approach to achieve robust urban navigation under adverse conditions.

The transformation of the data to global UTM coordinates is achieved through a process of coordinate conversion. In the event of satellite signal loss or visual occlusion, the Extended Kalman Filter (EKF) can be employed to dynamically fuse IMU angular velocity and acceleration data to ensure positioning continuity. Concurrently, the position information of surrounding vehicles is obtained through V2X communication [2], and the graph optimization algorithm (e.g., factor graph) is employed to realize multi-vehicle cooperative positioning.

Once the vehicle's location has been ascertained, an artificial intelligence-driven trajectory prediction is facilitated by a deep learning model, which aims to discern the motion intent of other vehicles [1]. The input data encompasses historical trajectory sequences, lane topology , V2X shared destinations, and real-time turn signal status. Spatio-Temporal Graph Neural Networks (STGCN) with Multi-Head Attention are employed to model vehicle-road-environment interactions. The model architecture employs a Transformer encoder-decoder structure, wherein the encoder layer utilizes multi-head attention to capture the speed difference, relative position, and lane offset between the other vehicle and the self-vehicle. Optimization of STGCN using multi-head attention mechanism, compared with optimization of STGCN using ordinary attention mechanism, the first approach is able to model multi-dimensional interactions (spatial+temporal+sem at the same time. It has a greater potential for dynamic interaction modeling and multimodal fusion. Moreover, optimization of STGCN using multiple attention mechanisms has not yet become a mainstream method, and has great research potential.The decoder layer generates multimodal trajectories in conjunction with the Diffusion Model (Diffusion Model) and outputs multiple candidate paths and their probability distributions. To ensure that the prediction results conform to the kinematic laws, a physically constrained loss function is introduced in the training phase [4].

$$\mathrm{MultiHead}(Q, K, V) = \mathrm{Concat}(\mathrm{head}_1 \ldots, head_h) \tag{1}$$

Accurate localization and prediction are crucial for safe and efficient autonomous driving. We propose a system combining AI, BeiDou navigation, and monocular cameras to precisely determine vehicle positions and trajectories. Using STGCN (Spatio-Temporal Graph Convolutional Networks), we interpret traffic behavior and model vehicle-road-environment interactions through graphical structures. STGCN excels in expressing graph topology, avoiding information loss or computational redundancy from road discretization, and provides clear physical meaning (nodes as vehicles/road points, edges as traffic limits). Our approach also includes joint optimization to balance localization and prediction, compensating for IMU drift and enhancing adaptability to dynamic environments.

References

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