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Trajectory Modeling Based on Plotting Information

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Abstract

Trajectory modeling or trajectory prediction plays an important role in self-driving mobility and traffic condition estimation. Given present location on a path, trajectory modeling aims to predict next one or more locations based on past information of the same trajectory. Intuitively, Markov chain and inverse reinforcement learning can deal with this kind of estimation within short-term dependencies, but problem becomes harder for long term trajectory by the same methods. We try to solve this problem by combining deep neural network and the geometrical trajectory information. With the pattern recognization ability of deep neural network, like convolutional neural network, we hope to achieve location prediction task directly using plotting information of graph network and trajectory. Besides, recurrent neural network will be used if necessary, such that long-term information dependencies can be detected and used to achieve higher prediction accuracy.

Problem

Many factors should be considered for trajectory modeling task, such as traffic condition, driver's personal preference and destination, and more importantly, the topological structure of road network, which makes the task hard to address. Current methods like Markov chain[1] and Inverse Reinforcement Learning [3, 4]have been used. These models are still too shallow as they eighter use first-oder Markov chain or the parameters used are limited. In addition, deep learning method has also been applied by using Recurrent Neural Network[2], it is said deep network outperform the above methods and achieve higher prediction accuracy. However, this work treats as most critical information the continuous coordinates, which we believe neglects the mutual relationship between trajectory and road network. Intuitively, these mutual information includes the topological adjacent or intersection relationship. We will use Convolutional Neural Network to extract the potential visual patterns, and then apply them in the location prediction task.

Formal Definition

Trajectory modeling is the prediction of the next one or more locations given previous locations on the same trajectory. Theoretically, it is to model the likelihood of a given trajectory with k known locations,

$$P(T) = P(r_1) \prod_{i=1}^{k} P(r_{i+1}|r_{1:i}) \tag{1}$$

where r_i and T are edges on a road and trajectory defined[2] as follows.

Definition 1 *(**Road Network**) A road network or road graph is modeled as a directed graph G(V,E), where V refers to the set of vertices (i.e., crossroads) and E refers to the set of edges (i.e., road segments). Each edge $r \in E$ corresponds to a road segment from a vertex $v \in V$ to another vertex $v'(\neq v) \in V$, where $r.s = v/r.e = v'$ represent the start/end of the edge.*

Definition 2 *(Trajectory). A trajectory T in the form of $r_1 \to r_2 \to \cdots \to r_k$ captures the movement of an object from r_1 to r_k along the road network G, where every two consecutive road segments are connected, i.e., $\forall r_i, r_{i+1} \in T, r_i, r_{i+1} \in E \wedge r_i \cdot e = r_{i+1} \cdot s$.*

Firstly, we draw a trajectory into several overlapping plotting using a sliding widow with fixed size, and each plotting will only contain segmentation of trajectory and the adjacent graph nodes from road network. And then we will use CNN method to conduct trajectory prediction. Finally, we may combine RNN and CNN methods for higher prediction accuracy.

Technique Difficulty

Data preparation is difficult as we will use opentreetmap to get road network; Besides, we treat the trajectory modeling as a computer vision problem, or specifically, a classification problem, which may arise unexpected problems.

Possible Outcomes

Successful trajectory prediction based on CNN (or RNN combined) model.

References

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