Graph-Based Lane Change Detection

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Introduction

One of the challenges of cognitive modeling is to reduce the representational complexity of real-world behavioral domains. Ideally we would like a data-driven approach that can analyze behavioral data and extract abstract and representative patterns from these data. The fields of pattern recognition and computer vision have similar problems in reducing complexity, and we hope to apply some of their algorithms to study human cognition. We have begun work in this direction by studying the complex domain of driving, and specifically the particular problem of understanding, modeling, and detecting driver lane changes (Salvucci, 2001, 2004, in press).

Approach

Given the different features for a driving scenario like speed, acceleration, steering angle, etc., we study the correlation among these features during a lane change. A layered graph, with each layer having n nodes (where n is the number of features such as lane position and heading) can be constructed. The edges in the graph go from one layer to the next and their weights represent the degree of correlation. Upon obtaining reference graphs for typical lane change instances we propose to match the input graphs with these reference graphs using efficient matching techniques (Shokoufandeh et al., 2005).

The input used in our study is a stream of data sampled approximately 14 times per second. We use overlapping windows of 2 seconds in duration, with each window beginning $1/2$ second after the prior window. We correlate each of the n features at interval t with those at interval $t+1$. Using the correlations we can either construct a complete graph where the edge weight is the correlation between the features, or we can construct an unweighted graph where an edge only exists if the correlation between the features is above a threshold.

Results

We show that there are surprisingly few different types of adjacency configurations across layers in these graphs. Moreover, we find that the same layers occur in tests both with different drivers and on different types of roads (straight vs curving). We construct an alphabet of layer types and apply error-resilient matching/editing algorithms (Levenshtein, 1966) to the resulting strings to extract common patterns in driver behavior.

Finally, we show that these graphs contain a great deal of periodicity as drivers follow common patterns such as changing lanes, following the curve of a road, and checking the rear view mirror. We apply object recognition algorithms to extract the canonical sets of lane changes and lane keeps which best represent typical driver behavior (Denton et al., 2004a, Denton et al., 2004b).

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