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主　論　文　の　要　約

論文題目　Integrating Context in Driving Behavior Modeling through Semiotic Analysis and Deep Learning
（記号論的分析と深層学習を用いた運転行動モデルにおけるコンテキストの統合）

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論　文　内　容　の　要　約

Fully autonomous driving has stayed as an elusive goal for researchers and the automotive industry for years. More recently, increased public interest and market potential precipitated the emergence of self-driving platforms with varying degrees of automation. However, robust fully automated driving in urban scenes is not achieved yet. An urban setting consists of elements with high unpredictability that call for an acute assessment mechanism. Usually, humans are the main culprits for the uncertainties, and not understanding their behavior causes tragic failures. Accidents caused by immature systems undermine trust, and furthermore, they cost lives.

The primary motivation of this dissertation is to develop a high-level artificial driving intelligence that can understand and describe a given driving scene. This challenging task is divided into two problems: assessing and describing a given driving situation automatically, and learning individual, unique driver behavior. The motivation behind this dissertation is discussed further in Chapter 1 and a detailed literature survey about driving semantics is presented in Chapter 2.

Oversimplification of complex causalities and relationships through heuristic designs are common in rule-based modeling. However, these methods often ignore the uncertainty of the real world. Crafting deductive theories leads to observing unexpected behavior, which manifests itself as unmodeled dynamics in engineered systems. As such, an inductive, data-centric approach is imperative for finding the best explanation of the observed driving phenomena, and it is the principal methodology of this dissertation.

Chapter 3 introduces a semiotic framework for assessing and describing a given driving situation in a new "driving language." This new language is a semantic construct

created by the following bottom-up unsupervised learning algorithms: the sticky Hierarchical Dirichlet Process Hidden Markov model (sHDP-HMM), the Nested Pitman-Yor Language Model (NPYLM) and the Latent Dirichlet Allocation (LDA). A real-world assessment task, detecting unsafe lane change instances, was achieved successfully with the proposed framework. A dataset comprised of 988 lane change scenes was utilized for this process. In order to understand driving semantics, ego-behavior and the *context* that they are executed in must be associated. The main contribution of Chapter 3, a novel symbol-*integration* method for conjoining ego-behavior and surrounding vehicle context, proved this claim by outperforming conventional and baseline methods. In addition, since the proposed semiotic framework converts raw data into a sequence of symbols, which is much smaller in size and much more descriptive, it can be utilized as an effective information transmission tool.

Chapter 4 introduces a novel method for learning individual, unique driver behavior. An unsupervised deep learning framework was designed for this purpose. First, 46 different drivers' ego-behavior data was used to train a stacked Autoencoder (AE) network. Then, the final AE layer's encoded feature vectors, the driving signatures of all drivers, were clustered into three global driving style groups with the K-Means algorithm. These learned features were *integrated* as *context* into a car following model to predict driver behavior. Experiments in a simulation environment showed that behavior prediction greatly depends on driving style recognition, as the proposed method outperformed conventional and baseline car following models.