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主 論 文 の 要 旨

論文題目　**Analysis, modeling and application of personalized driving behavior based on multi-mode dynamical systems**
（マルチモード型動的システムに基づく個性化運転行動の解析，モデル化とその応用）

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論 文 内 容 の 要 旨

Since the introduction of the first mass produced vehicle, the Ford Model T in 1908, the automotive has been a vector of movement for millions of persons. Up to this day, the enthusiasm for the property of personal vehicles led to a non-stopping increase of the number of vehicles on the planet. This global interest toward motor vehicles rapidly extended to a reflection on broader topics, such as city urbanization and planning, and infrastructures management. It created new subjects of research, such as vehicles modeling, drivers modeling, or traffic flow modeling. With years, these topics led to concrete applications such as city traffic flow optimization in the process of designing new road infrastructures, advanced driver-assistance systems (ADAS) for driver safety and comfort.

This thesis work is focused on the analysis and the modeling of behavior personalized human driving dynamics in car-following situation. The car-following situation has been selected for its ability to scale to the widest range of problems: it can be used for human cognition understanding, trends analysis, traffic flow modeling, advanced driving assistance systems, and vehicle powertrain design. The goal of this research is to find and propose a general method to analyze and to model individual driving dynamics.

This research begins in **Chapter 1** by a deep review of sixty years of driver modeling, followed by explanations about essential points on the human driving modeling and on the main modeling methods used to this day. This chapter also presents the goals, the methods and the organization of the research to clearly understand our proposal. According to the literature and to the analysis of the proposed driver modeling methods, it could be observed that multi-mode dynamical system models provide a complete framework for human driver analysis and modeling. As such, the Piecewise Autoregressive Exogenous (PWARX) and Probability Weighted ARX (PrARX) models are remembered as being the best model candidates.

After this general introduction, **Chapter 2** details the method used to analyze and model the human driving behavior. The six measurement campaigns are explained, involving a driving simulator and real instrumented vehicles, and general data analysis is shown. Then detailed explanations are proposed about multi-mode dynamical system models, to provide to the reader the required knowledge for the understanding of the research applications.

Chapter 3 proposes a framework to show the ability of a standard PrARX model to reproduce car-following situation. The framework is developed so that any car-following model can be implemented, enabling direct comparison between models. The model comparison is proposed with three of the most used car-following models. Advantages and disadvantages of each method are explained. The result of this comparison proves that the PrARX model can be used for driver modeling, and it does explain that the PrARX model is more likely to behave like a human being than simple car-following models.

In **Chapter 4**, a solution is searched to accurately model behavior personalized fuel consumption. Based on the modeling experience gathered in Chapter 1 and Chapter 3, and on the driving measurement data collected in Chapter 2, a modeling framework based on a custom implementation of the PrARX model is proposed. This framework includes a data selection method, a model input-output configuration and a performance criteria for the evaluation of the model accuracy. The real-world simulation cases show results with fuel consumption estimation errors from -0.06% to -3.8% depending on the driving style. These results prove the ability of the developed framework to model personalized driving dynamics.

Chapter 5 proposes a novel method for driving behavior analysis. This method is based on the observation of the evolution of driving style over time thanks to identification of time-varying model parameters with a custom sequential Monte-Carlo approach. The goal of this method is to be able to extract information about the driving behavior consistency over time. This method is applied to Gipps traffic flow model and to a PWARX model. The parameter identification method shows good results on demonstration examples, including cases with real-world measurement data. Moreover, a first example of analysis of driving behavior based on a model parameter evolution is proposed, and soft drivers behavior can be differentiated from aggressive drivers behavior.

Finally, **Chapter 6** concludes the research by proposing a summary of the thesis work and recommendations for future works. This research provides a perspective and analysis of driving behavior from driving simulator and real-world measurement data, a method for driving behavior analysis from model parameters interpretation, and two frameworks for personalized driving behavior modeling using the multi-modes dynamical system models. We hope that the future applications of this research will enable to analyze and model not only the global tendency of each individual driver behavior, but also the personalized driving consistency over time, depending on the driver and the environment state.