



PhD Proposal 2016

<u>School:</u> Ecole Centrale de Lille	
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Collaboration with other partner during PhD: In Sweden: Lei FANG (KTH) lfeng@kth.se	In China: Zhuoyue SONG BIT szhuoyue@bit.edu.cn
Title: Modeling and Simulation in Vehicular Ad hoc Networks (VANETs)	
Scientific field: Advanced Control, Optimization & Simulation	
Key words: Intelligent Transportation Systems (ITS), Optimization, Traffic Simulation, Virtual Reality, Performance Analysis	

• Context:

- Cooperation program between Professors Liming ZHANG (U. of Macau) and A. EL KAMEL (EC Lille/CRIStAL) started in 2013
- Cooperation program between Professors Zhuoyue SONG & Yue YU (Beijing Institute of Technology, BIT) and A. EL KAMEL (EC Lille/ CRIStAL) started in 2012
- Cooperation program between Professors G. GONG (Beihang U., BUAA/AST Key-Lab), S. WANG (Beihang U., BUAA/MC Lab) and A. EL KAMEL (EC Lille/ CRIStAL) started in 2007
- Joint project, involving the 3 partners in the frame of China-French Network LIA 2MCSI
- A. EL KAMEL is Regular Visiting Professor to BUAA since 2008 involved in KEY-Projects, to BIT since 2013 in charge of two courses and to U. of Macau
- Visiting Professor position at EC Lille to G. GONG (2009), to S. WANG (10) & to Z. SONG (15)
- 6 CSC-supported PhD dissertation by Jin ZHAO in 2010, Minzhi LUO in 2012, Yue YU & Tian ZHENG in 2013, Daji TIAN in 2014, Chen XIA in 2015, Bing LIU in 2016
- 3 Chinese PhD students, with CSC support, are now working in my Research Group

Detailed subject

• Background:

Transportation research and development are no longer a field dominated by civil, mechanical, operation research, and other traditional engineering and management disciplines, but it is an interdisciplinary field. Intelligent Transportation Systems (ITS) are complex systems, in which various factors such as human, vehicle and environment interact with each other, and abundant information is multi-sourced, heterogeneous and unstructured.

The development of ITS requires extensive testing, verification and evaluation of new traffic concepts. Therefore, many traditional technologies are severely limited so as to be disabled in this area. Modeling and simulation (M & S) have been identified as important steps in realizing the transportation initiatives. It is widely used in the design and test of intelligent vehicles, to complement experimental results as well as to analyze different control algorithms in different traffic situations and environment, where realistic experimental tests with real vehicles would be hard to accomplish due to hardware and vehicle availability problems.

Traffic simulation provides a flexible, effective and safe way to research innovative concepts and applications. Virtual Reality (VR) technology and Multi-Agent System (MAS) are increasingly being used in transportation system, especially for traffic simulation. Thus this thesis combines the traditional ITS with VR and MAS to research on the microscopic traffic simulation system, including systematically investigating the modeling method of vehicle simulation, integrating intelligence into vehicle simulation framework, and researching on the interactions among the vehicles, the traffic situations and the environment.

In our group, a Virtual Reality Intelligent Simulation System of Vehicles (VR-ISSV) is designed. VR-ISSV researches on the interactions among the vehicles, the traffic situations and the environment information, especially intelligence is integrated into vehicle simulation framework based on multi-agent. Multi-agent technology sufficiently reflects the thought of the artificial intelligence and is a more suitable method for constructing VR-ISSV. Based on multi-agent technology, the study focuses on the modeling methodology of VR-ISSV and its some key aspects. The goal is to build up the systematical modeling methodology for VR-ISSV as well as to improve its intelligence and scalability. Multi-agent based VR-ISSV has the characters of reusability, scalability and flexibility, which could realize the rapid construction of VR-ISSV with model re-configurability and code reusability.

Autonomous vehicles and V2X communications are two booming directions in the research of ITS. It is believed that these two kinds of technologies are important backbones of ITS. The combination of the two directions could bring revolutionary change to transportation systems. How the participants interact with each other in order to achieve optimal social benefits needs to be researched.

Two major aspects are to be considered also at the design & simulation level:

- Energy efficiency of the transport infrastructure: optimizing the road altitude profile to minimize energy consumptions of caravan of vehicles running on it. In many driving scenarios, the vehicle follows a fixed speed profile. If the road is designed in such a way that the vehicles always accelerates/decelerates on a down-/up-hill, then the fuel consumption can be reduced.
- Integration of supervisory control theory and formal methods: their systematic integration is effective for enhancing the power of both methods. One research plan is to extend our results on divide-and-conquer using dependency analysis and hierarchical model abstraction using equivalence relation to applicable techniques in formal methods.

□ **Work plan, Research program:**

- Modeling autonomous vehicles and roadside units
- Modeling communications in VANETs
- Developing applications of VANET in order to build intelligent transportation systems: improve safety and efficiency
- Simulating the applications designed in VR-ISSV or other traffic simulator in combination of network simulator
- Simulating the interaction between vehicles and infrastructure, between vehicles and the interaction between autonomous vehicles and human-driven vehicles including energy efficiency aspects.
- Investigating by simulation the influence of communication quality on the applications
- Extend and consider integration of supervisory control theory and formal methods.

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