# PhD Proposal 2016

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**Title:** ITS Control & Optimization  
**Scientific field:** Advanced Control, Optimization & System Reliability  
**Key words:** Intelligent Vehicle Control, Decision Making & Optimization, Traffic Simulation, 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 PENG, Zhuoyue SONG & Yue YU (BIT) and A. EL KAMEL (EC Lille/CRiStAL) started in 2013  
  - Cooperation program between Professors G. GONG (BUAA/AST Key-Lab), S. WANG (BUAA/MS Lab) and A. EL KAMEL (EC Lille/CRiStAL) started in 2007  
    - Joint project, involving the 3 partners in the frame of LIA 2MCSI  
    - A. EL KAMEL is Regular Visiting Professor to BUAA since 2008 involved in a KEY-Project  
    - Visiting Professor position at EC Lille to G. GONG (2009) & to S. WANG (2010)  
    - 4 Chinese PhD students, with CSC support, are now working in my research team

**Detailed subject**  
**Background:**  

Intelligent Transportation Systems (ITS) is a key research and development area no longer dominated by civil, mechanical, operation research, and other traditional engineering and management disciplines, but is nowadays an interdisciplinary field. ITS and AHS 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. Implementation of these systems requires the new generation of intelligent vehicles.
The development of ITS and AHS 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 conditions, where realistic experimental tests with real vehicles would be hard to accomplish due to hardware and vehicle availability limitation & costs.

Several CSC-sponsored PhD thesis where carried out in my research team on this topic, under my supervision & in cooperation with Chinese colleagues, brilliantly defended by Jin ZHAO (2010), Minzhi LUO (2012), Yue YU (2013) & Tian ZHENG (2013), Daji TIAN (2014) and Chen XIA (2015). Hence, a recent PhD work has been carried out to develop the multi-agent-based virtual reality intelligent vehicles simulation platform, which is a hierarchical modular modeling and simulation system consisting of hardware, network and operating system layer, visualization management layer, multi-agent layer, human-machine interface layer. A decentralized design paradigm is used for developing the multi-controller based intelligent vehicle, whereby the car following behavior and the overtaking behavior could be realized by the coordination of multi-controllers. The environment is constructed based on the conception of Synthetic Natural Environment (SNE), taking into account the interaction between the vehicles and the natural environment. Geographic Information System (GIS) is used to establish environment model. Furthermore, to ensure the safety in microscopic traffic maneuver, the intelligent vehicle controllers adapting to complex environment are considered. Fuzzy logic based controllers & Intelligent vehicle learning in autonomous navigation are designed for sending the appropriate outputs to the vehicle’s actuators – the steering wheel and the throttle/brake pedals. Microscopic traffic behavior models involving environment are studied thoroughly.

- **Work plan, Research program:**
  - To expend the capability of the intelligent vehicle platform.
  - To improve & optimize controllers & on-line learning and adaptive control.
  - To enrich the mathematical vehicle model and the control model by considering the driver state, such as fatigue, emotion ...
  - To improve simulation performance & system reliability.
  - To construct the intelligent optimization models. These optimization algorithms can be encapsulated in the Dynamic Link Library (DLLs), which can be flexibly called.
  - To use mixed reality – virtual environments to verify the vehicle control algorithms and microscopic traffic behavior models.

- **References:**
  - Bing LIU and Abdelkader El Kamel. "V2X Based Decentralized Cooperative Adaptive Cruise Control in the Vicinity of Intersections". Accepted for publication in IEEE Trans on ITS. September 2015.
  - Yue Yu, Abdelkader El Kamel and Guanghong Gong. HLA-Based Design for Intelligent Vehicles Simulation System. In IEEE Conference on Computational Engineering and System Applications, pages 139-144, Chile, April 2012.