école doctorale **sciences pour l'ingénieur et microtechniques**

SUBJECT FOR THE INSA-UT PHD PROGRAM OF THE CHINA SCHOLARSHIP COUNCIL

PhD title: Safe driving for cyclists: Design of a system for signaling and optimizing interactions with other road users

Host laboratory: Connaissance et Intelligence Artificielle Distribuées (CIAD) – http://www.ciad-lab.fr

Belfort, FRANCE

Specialty of PhD: Computer Science

Keywords: Artificial intelligence, Operations Research, Signaling systems, Optimization of cyclist/vehicle interactions, Virtual reality

Detailed description of the thesis:

Introduction / Context

Climate change and its effects are pushing us to focus on green and sustainable transportation and to focus our scientific research on better understanding and promoting sustainable transportation such as walking and cycling. Communication between cyclists and drivers is not always easy. Cyclists use hand signals and audible signals to communicate with other road users. These techniques are not effective because the cyclist cannot discern whether the driver of a vehicle is aware of his or her presence and intends to give the cyclist enough space, especially if there are multiple vehicles present. Similarly, audible communication may be masked by traffic noise or dampened by the soundproofing of the vehicle. The advent of autonomous vehicles (AVs) may alleviate some of these problems since with their built-in systems these vehicles can communicate their knowledge and intent to cyclists (e.g., indicating that the vehicle is at a safe distance from the cyclist), which could help cyclists make better decisions about when to merge, change lanes, or pass. But research in this area has focused on the technological challenge of cyclist detection with little or no attention to the optimization and safety of interactions between cyclists and other road users.

Detailed objectives

The main objective of this thesis is to propose approaches aiming at allowing better cooperation between cyclists and other road users (pedestrians, autonomous vehicles...). These approaches aim in the long term to make cycling in the city pleasant and enjoyable. They also aim to reduce the risk of death and injury in urban areas for vulnerable road users (VRU) and to encourage clean and safe modes of transport in urban environments.

There will be two main axes to consider in this thesis work:

1. The first axis concerns the **modeling of cyclists' behavior** in urban environments when faced with dangerous situations and the **design of a signaling system** for information sharing between cyclists and vehicles.

2. The second axis aims to **build algorithms** to manage and secure interactions between cyclists and other users, whether on the road or at intersections. Optimization methods from operational research will be used to secure the different interactions while keeping the traffic flowing.

Phases of the thesis

First phase: State of the art and analysis of the existing literature

A study of the existing models of cyclists' behavior and communication systems with other road users will be conducted to define the different scientific barriers.

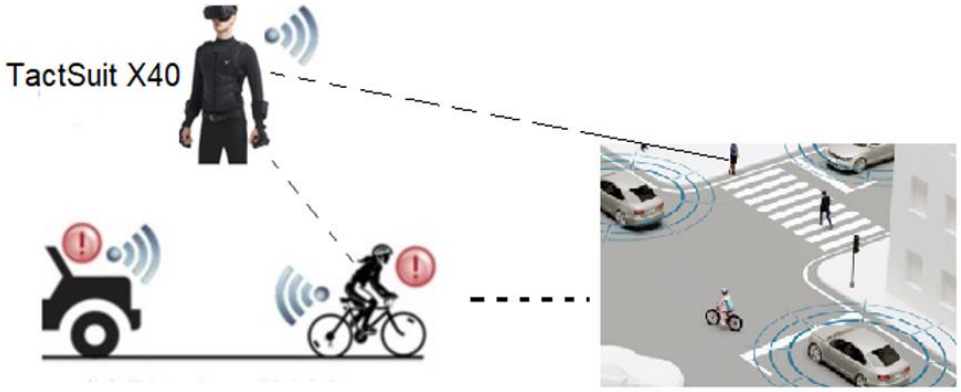
Second phase: Design of the virtual environment for the study and development of a model of cyclists' behavior

This phase consists of conducting a study to develop a model of cyclists' behavior. The study will be done on about fifty participants with very varied profiles. These participants will be able to navigate in a virtual environment developed (with unity3D and SUMO framework) beforehand by a trainee with several possible road scenarios. This environment will involve different pedestrian and vehicle dispositions. The goal will then be to observe how cyclists behave in VR compared to a real scenario and to evaluate their perception of danger and road users, especially autonomous vehicles. This study will thus provide us with the appropriate elements that will allow us to develop and describe a model of the behavior of these cyclists.




Third phase: development of the signaling including innovative solutions for the management, optimization, and security of interactions.

The study of cyclists' behavior will allow the implementation of signaling tools and visual navigation aids, auditory and haptic aids (located for example on the handlebars or helmet or a belt). Right-of-way decisions within intersections and priority rules will also be proposed and will be evaluated in terms of relevance and acceptability from both the perspective of AV passengers and cyclists. The Ph.D. student will finally develop a "cyclist-vehicle-pedestrian" signaling system in which all navigation aids (visual, auditory, and haptic), all previously developed rules for priority management, and all right-of-way decisions within intersections will be simulated and integrated (decisions resulting from optimization algorithms for different types of criteria: travel times, waiting at intersections, ...).



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Candidate Profile:

- The candidate should have a strong background in computer science (Master level).
- A mastery of tools related to Virtual Reality (Unity, immersive headsets, etc.) would be an undeniable plus.
- An advanced level in English (writing and speaking) is required.

Supervisor:

Supervisor: Pr. Mahjoub DRIDI