Abstract

During the last decades, Intelligent Transportation Systems (ITS) mainly focusing on improving traffic conditions and traffic safety have attracted the interest of researchers and academia. However, very few approaches have been focused on the discriminating characteristics of Powered Two-Wheelers (PTW) traffic and how these may affect the ITS architecture and operability, especially when technological advances in Vehicle-To-Vehicle communications are advancing fast. The aim of the specific PhD dissertation is to examine the decision process of drivers during overtaking by PTW and their strategic interactions with the rest of the traffic.

A literature review on the subject is conducted revealing significant findings. Firstly, one of main difficulties researchers face when it comes to studying PTW phenomena is the lack of real data of their complex manoeuvres and unconventional trajectories that cannot be easily be tracked or modelled using simulation approaches. As a result, the use of modern technologies as a mean of recording traffic streams is discussed, reviewed and proposed. Moreover, overtaking phenomena have been previously documented mostly for cars, without taking into account the distinct way PTW move in traffic. In addition, although ITS are in the active parts of research, they have not yet been extended to support PTW traffic applications based on cooperation and how they could improve traffic conditions, except for limited safety oriented systems.

In order to create a detailed naturalistic PTW trajectory database, the innovative use of Unmanned Aerial Systems (UAS) was preferred. While most researchers have been using stationary cameras to monitor traffic, numerous issues can emerge when it comes to monitoring an extended arterial and the presence of hidden points while tracking vehicles. While UAS (commonly known as drones) have been in the centre of attention for military or entertainment purposes, it is found that they have the potential to become a crucial part of ITS infrastructure as an eye-in-the-sky solution. Using UAS and advanced computer vision techniques, detailed data of over 400 overtaking cases was collected.

In addition, the specific database paved the way for advanced methodological tools. Decision Trees and other meta-algorithms, a special case of Machine Learning (ML) models, are developed in order to model the unconventional overtaking patterns of PTW drivers. The developed decision tree models enable the identification of the

significant factors during overtaking such as speed difference, spatial factors and vehicle type and positions. The two-high performance predictive two models can be used in the design of modern ITS.

Then, the interactions between PTW and the rest of the traffic are examined. Using the concept of Game Theory, both the PTW driver and the preceding vehicle's driver are assumed to be rational decision-makers that develop strategies, trying to maximise their payoffs. These strategies may be cooperative or not with respect to distances and safety gaps, while other behavioural aspects are also taken into account. Using advanced statistical methods and structural equation modelling an innovative variable named as "Comfort at Overtake" is created to describe the supplementary to high speeds factors that are connected to overtaking such as safety of the individual driver-vehicle system, joy of driving and social welfare.

Results show that cooperation can emerge, even in a competitive environment as the roads are. The advantages of cooperation can be detected in increased average speed of all vehicles, increased "Comfort at Overtake" and increased percentage of successful overtakes. Findings also revealed that taking advantage of the high accuracy models, the cooperativeness in mixed traffic conditions could be enhanced and conspicuity issues frequently met when vehicles interact with PTW could be tackled.

Then a discussion arises as to how this conclusion can be a critical in the design of innovative applications and services and set the framework for an assistive system. Specifically, by using wireless communication and data transmission, it could suggest the PTW driver whether the traffic conditions upstream are adequate for a safe and comfortable pass to be completed, while the administrator of a road network can change traffic parameters by optimizing cooperation conditions.

The state-of-the-art of the PhD dissertation are summarized in the innovative use of Unmanned Aerial Systems as part of the ITS infrastructure, in the new way of approaching interaction of different types of vehicles, in the use of advanced Machine Learning techniques and in the application of Game Theory to overtaking phenomena. The contribution of results and findings from the modeling of driver decision-making and the interaction of different types of vehicles is of particular importance for the design of modern Cooperative ITS, particularly in an environment where V2V technologies, autonomous and Connected Vehicles are among the hot topics of the international research community.