

# **SESSION 3 :**

# **INTELLIGENT TRANSPORT SYSTEMS**



# REPRESENTATION OF KINEMATIC DRIVING BEHAVIOUR USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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## ABSTRACT:

Naturalistic driving studies generate large data volumes, which are complex to handle and manage. Until now, most part of these studies have been carried out by research groups with limited resources. For this reason, the tools implemented for the processing and analysis of data tend to be focused on very specific applications and research topics. In addition, software and

tools commonly used are implemented *ad hoc*, showing a limited operational capacity. For these reasons, it is relatively frequent to apply strategies to reduce data volumes and to offer partial solutions.

An alternative procedure is related with the use of *Geographic Information Systems* (GIS), which overcome many of the drawbacks of the methodologies and tools previously described. The powerful interface graphics and high operational capacity of these GIS systems can obtain a clearer representation of data, enabling to reach more optimal and efficient use of these data. Some concrete examples are proposed.

## 1 INTRODUCTION

Road traffic is one of the themes more studied in today's societies, which are more prone to mobility due to the constant increasing number of vehicles, urbanization and new social trends. Within this context, one of the hottest topics is the related to road safety [1]. In fact, road fatalities have a huge impact on number of dead and/or injured people, social costs related to the transfer and care for the injured people, and management of traffic flows just after accidents, among other consequences. For this reason, it becomes increasingly important to deploy prevention policies to manage the infrastructures and road flows, in addition to provide a quick and efficient response under in emergency situations [2].

Most of the studies published in the past analyzed the road safety from the perspective of the different elements (i.e. vehicle, driver, road, and surrounding environment) involved, but in isolation. Some recent studies suggest the growing need for integrating multiple research perspectives and the maximum number of elements which can affect driving performance [3].

In recent years, a new method of experimentation applied to the road safety has been introduced: Naturalistic Driving (henceforth ND). ND enables to characterize the driving behaviour of a group of people in

real-world situations. This method enables to observe unobtrusively the driver, vehicle, road and traffic environment as well as the interaction between all these factors. The observation process is carried out under objective conditions and requires the continuous monitoring of the driving performance for each people and situation. Significant number of studies related to naturalistic driving have been published (such as [4-6]), being the two most ambitious the 100-car and the SHRP-2 Naturalistic Driving Study, both in USA [7-9].

Data collection in ND is described as a massive and blind process. It is massive because it collects data about each factor which (actually or potentially) affects the driving performance, whereas it is blind because there is not a specific target during the procedure for data capturing. Data finally collected are highly versatile and can be used from multiple research perspectives relative to vehicle, infrastructures, environment and driver [10] [11].

ND has two main advantages compared to the experimentation methods traditionally used: (a) the experimental process is unconditioned because the minimal intervention of research staff, and (b) enables to assess a great number of parameters which have (or can have) influence on the driver's behaviour. In [12] is concluded that certain factors such as reckless driving, inexperience, carelessness, loss of vehicular control were responsible of the most part of the fatalities observed in the Kumasi-Accra highway (Ghana). However, the relative importance of each one could not be quantified, because driving performance cannot be continuously observed under real-world conditions.

Despite its advantages, some drawbacks are associated to ND such as the high resource requirements in terms of sample size and duration during data collection, and related to the gathering, storage,

reduction, analysis and interpretation during data processing. These requirements explain the (not infrequent) presence of gaps and missing data [13] [14]

ND requires new tools and representation models because the great number of kinematic parameters collected. Most of ND studies published until now are trying to reduce the analysis to small road sections or specific events because these high requirements. However, a right exploitation and visualization of data would be able to increase the potentiality of analysis and the reliability of the results finally obtained.

Some previous studies about ND used mathematical and statistics software or, in alternatively, have developed their own tools. Lassarre et al. [15] recommended the implementation of a proper algorithm for the computation of relevant indicators in software such as Matlab, Excel or SPSS. Gatscha et al. [16] developed a tool for analyzing small datasets which can be integrated into SPSS. Jovanis et al. [17] proposed a system for predicting the decisions of drivers based on MLwiN 2.0. Val and Küfen [18] implemented their own software in Matlab, while Dozza [19] made the same (SAFER100car) for analyzing specifically data from the project 100-car NDS. A more complete revision of the tools used for processing and representation of data obtained in previous ND studies is carried out in Balsa-Barreiro [20] Until now, almost none of the ND studies previously carried out used Geographic Information Systems (henceforth GIS). Uniquely Gordon et al. [21] considered very briefly the relation between ND and GIS, although only applied to geolocate concrete events such as crashes.

The current conference paper is focused in the potentiality of GIS systems for representation of ND data. This theme follows the

research line introduced in former studies of the same authors where two different GIS methodologies applied to ND studies were proposed: (a) for estimating the positioning data

that have been unregistered [22] [23], and (b) for establishing quality control procedures on the data obtained [24] [25].

The current conference paper is structured as follows: objective (section 2), data and studied area (section 3), methodology and results (section 4), and finally, brief discussion and conclusions (section 5).

## **2 OBJECTIVE**

The objective of the current conference paper is to propose the GIS mapping as standard methodology for the representation of driving behaviour, which can be estimated from kinematic data collected in ND studies. Thus, according with this purpose, some examples are shown.

## **3 DATA AND STUDIED AREA**

The data used here were obtained from Prologue, one of the most representative attempts for carrying out a ND study at European level [26] [10]. In Spain, a pilot study derived from Prologue was carried out by INTRAS (University Research Institute on Traffic and Road Safety) in the surroundings of Valencia (the 3rd most populated city) during the months of June and July of 2010. Five drivers participated for four days everyone during two hours per day. A vehicle highly instrumented, named Argos, was used in this trial. Diverse parameters were recorded using several instruments and devices, and considering different temporal frequencies for data recording. Most part of the kinematic parameters were recorded with temporal frequencies of one centisecond (10-2s). A more detailed description of

the measuring instruments used by the Argos car and more information about the Spanish trial of Prologue can be found in [27].

Data used in this conference paper are related to the driving (kinematic) behaviour of the different drivers in concrete sections of the V-21 motorway between Valencia and Puzol (Spain), a route of approximately 16 km which was traveled in the driving direction S-N. This route is the same considered in previous studies such as [22-25].

## **4 METHODOLOGY AND RESULTS**

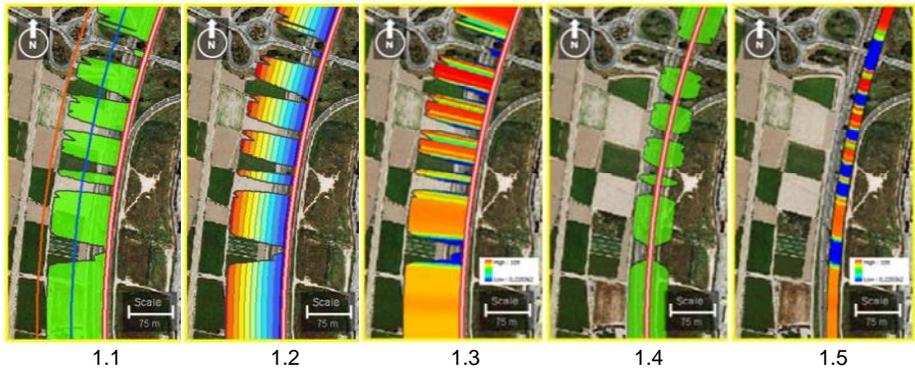
Representation of kinematic data firstly requires the discretization of the lineal entity which corresponds to the route. This is divided into point entities separated one meter each other. These point entities are the basis for the representation of the kinematic data. For this, some geoprocessing operations and the use of different attributes are required for mapping, which offers a simpler and clearer representation of the data.

Length of the road section represented in the figure 1 is about 600 m, and is located at the first part of the studied route. This road section corresponds with a curve to the east, which is previously preceded by the steeper slope. The speed of the one single driver in a concrete day is represented in the figure 1. Data show a continuous variability with very frequent extreme fluctuations in very short road sections because the eventual traffic jams and the clear presence of missing data [25].

Various mapping results are proposed here. Firstly, the speed parameter is represented by a semi-buffer projected onto the left part of the route (figures

1.1 to 1.3). In addition to the geometries, the use of others attributes such the colour leads to obtain a clearer representation of the speed parameter. Figure

1.1 shows a geometric representation using a polygon single-coloured. The scaling is carried out via two speed isolines: 60 km/h (in blue) and 120 km/h (in orange), the minimum and maximum permitted speeds respectively. Mapping result shown in the figure 1.2 is based on a multiple buffer parallel to the route path, in which each line represents a speed difference of 10 km/h regard to the previous one. In addition to geometric attributes, a discrete colour palette is established. Thus, it is observed a reiteration between data represented by the geometries and colours, which change for each speed isoline. In the figure 1.3, such as the previous figure, both colour and geometry attributes are combined. However, the colour here is based on a continuous degradation (raster model).The mapping result of the figure 1.4 is established by a complete polygon single-coloured obtained from a buffer projected onto either side of the road path. This figure shows a superlative vision of the parameter represented. Finally, the figure 1.5 is based uniquely on colour attributes, but not considering any geometric attribute.



**Figure 1. Different mapping results for the speed parameter of one single driver**

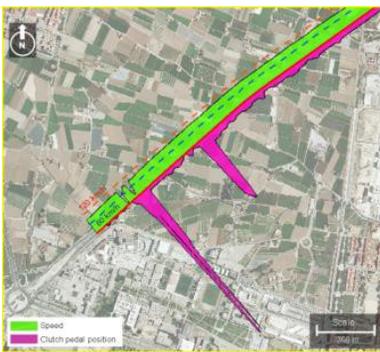
Road section represented in the figure 2 corresponds to the initial route path and it is about 1.7 km. This road section, in which the vehicles are incorporated to the motorway, is mainly straight. Here, different kinematic data related to driving performance of one single driver during the same day are represented (figure 2). Vehicle speed, clutch pedal and accelerator position are simultaneously mapped in the figures 2.1 and 2.2. In the figure 2.3, three different kinematic parameters are simultaneously represented (engine running speed, accelerator and clutch position), while in the figure 2.4 are represented four (engine running speed, gearshift, accelerator and clutch position).

Data are simultaneously represented using layers, which can be partially overlapped. The management of data layers depends on the research interests. This representation mode leads to clearly review the data, being possible to assess the levels of correlation and interdependence between the different kinematic parameters. Thus, mapping results of the figure 2 can analyze more deeply different

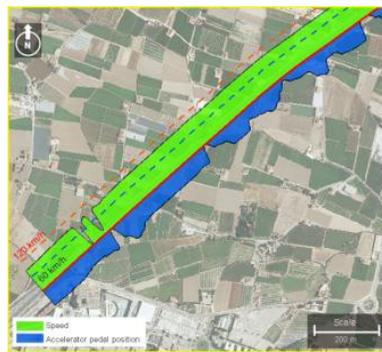
aspects such as the driver's incorporation to motorway or how the increasing gearshift is performed for each driver by observing the position of the clutch and accelerator pedals, and by considering the engine running speed of the vehicle in each moment.

## 5 BRIEF DISCUSSION AND CONCLUSIONS

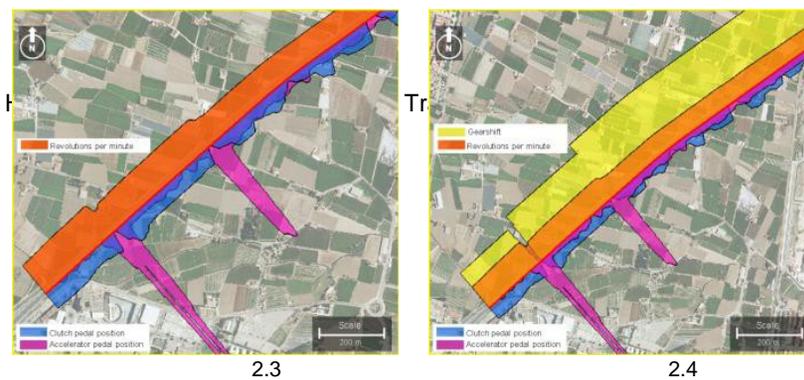
Data obtained in ND studies offer a wide range of possibilities for research. ND studies require the integration of multidisciplinary working groups, novel analysis' approaches and new tools for obtaining a clearer and simpler data representation, which encourage the former purposes. However until now, the tools commonly used, which are mostly based on a quantitative focus [28], show some drawbacks such as unfriendly user interfaces, hardly intuitive displays or low levels of performance.



2.1



2.2



**Figure 2. Mapping results for some kinematic parameters related to the performance of one single driver during the same day**

Use of GIS systems in ND studies enables to overcome some of the common drawbacks of software tools traditionally employed, leading to obtain an easier and more efficient management of data. GIS systems normally provide a simple and friendly interface, which is easily operable by any user, not being required an expert knowledge, and encouraging the incorporation of multidisciplinary working teams to this field of knowledge. This leads to the openness to more creative solutions to help "solve" a multi-faceted problem as it is road safety [3]. Furthermore, integration of ND data into GIS can reach a more extended perspective of data, not only reduced to small datasets such as defined by limited areas and concrete events.

Most road traffic studies which currently use GIS systems, not solely based on ND observation, are focused on the representation of incidents and parameters which are statics. This conference paper shows some concrete examples about how kinematic parameters obtained in ND studies can be represented by GIS systems. Discretization of data which are continuously recorded, use of geometric and colour attributes, in addition to employ of techniques such as multilayering or overlapping are proposed. Examples shown

offer a clearer data representation, which greatly simplifies and facilitates subsequent phases related to the analysis and interpretation of data.

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