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Contents

New system for the automatic counting of vehicles in roundabouts and intersections

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1 Introduction

Traffic management is increasingly important due to the high density of vehicles on the road network, together with the increase in the loads transported and the increase of the circulation speeds.

These factors lead to congestion problems on all types of road infrastructure, both urban and interurban, which, due to their high impact on society, have been quantified economically. In this sense, the annual cost of traffic congestion in Spain is estimated at approximately 5,500 million euros, with per capita expenditure reaching 1,000 euros per year.

In this sense, for a correct traffic management, it is very useful to have detailed and real-time information on origin-destination matrices, that is, matrices that show how many vehicles come from each specific origin (O) and go to each destination (D) determined, so that the managing body of the circulation is able to make the best decisions as quickly as possible.

Traditionally, the recording of data to carry out these origin-destination matrices has been done by manual counts on the site. However, they are only recommended for short periods, not exceeding 24 hours, as their high cost makes their use for longer periods unjustifiable. An alternative to this system, which allows to obtain origin-destination matrices at intersections continuously would be the license plate recognition systems. These systems have certain technical drawbacks as they require the installation of cameras at height that can be affected by inclement weather, traffic congestion, day/night transition light, contrast vehicle/road, among other causes; it is elevated probability of failure makes it an unreliable system.

For this reason, a system has been proposed that is capable of, using the analysis of the records provided by a network of sensors (accelerometers and magnetometers), classifying the type of vehicle that passes through an intersection and at the same time generating origin-destination matrices in real time. Therefore, a tool is provided for the optimal and precise

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management of traffic, which will make it possible to avoid traffic jams in a high percentage and, in any case, quickly reduce them, knowing the mobility patterns of the vehicles at any given time.

2 Methodology

As mentioned above, the design of a system capable of automatically and accurately generating origin-destination data at intersections was proposed. Therefore, this section tries to explain the methodology used by the system.

i. **Data logging.** This phase is carried out by means of a system of wireless nodes, which includes 5 magnetometers and 6 accelerometers embedded in the pavement. The system is capable of recording the vibration data generated on the pavement surface and the magnetic impression of all the vehicles circulating on it.

ii. **Data processing.** This phase includes the algorithm necessary for the processing of the data. Two algorithms are used for this:

- **Vehicle classification algorithm.** Firstly, this "classification algorithm" is composed of a system for calculating speed through the signal emitted by the magnetometers, an axle detection algorithm with the information provided by the accelerometers and with the results of these two algorithms a third algorithm has been developed to classify the detected vehicle. A diagram of the process is shown in the Figure 1.

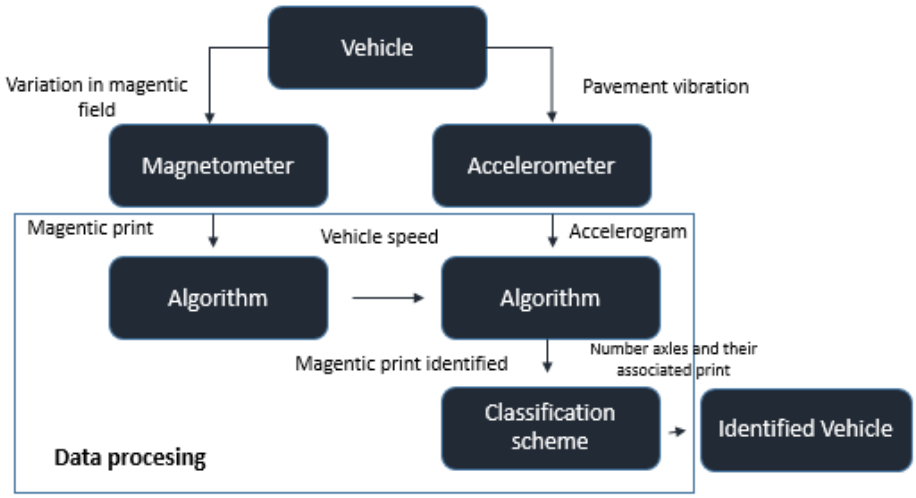

Figure 1: General classification vehicle algorithm. Sources: [1]

- **Re-identification algorithm.** Secondly, the re-identification algorithm whose correct operation is essential for the system to have an adequate performance. This second algorithm starts with the filtering of the signal received by the magnetometers. Once the signal is filtered, it is necessary to identify when a vehicle is started and stopped in order to extract its magnetic print. Once the print is extracted it will

be compared with the prints of other stations in order to identify the entry and exit point of the same vehicle. In order to make the comparison more reliable and robust, several magnetometers have been placed in the same station with the aim of having several samples of the same print. Obviously it has been necessary to establish a system of comparison of tracks, this has been done through cross-correlations. A diagram of the process is shown in the Figure 2.

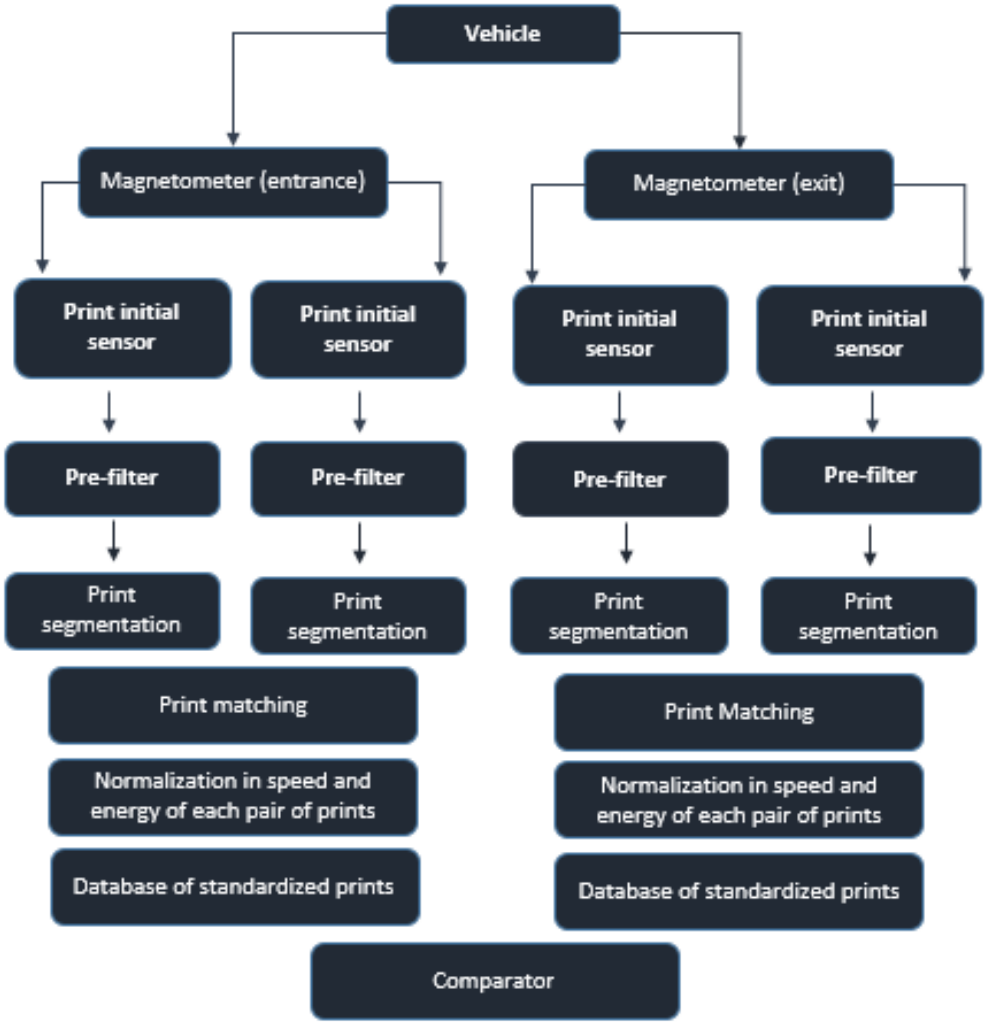

Figure 2: Re-identification algorithm. Sources: [2]

The complex methodology exposed has been checked and verified in controlled conditions, so we will try to explain the results and conclusions obtained.

3 Results and discussion

To verify the correct operation of the algorithm, it is necessary to subject it to different tests.

First, the tests were carried out under controlled conditions. In them, registers were executed using both types of sensors (accelerometer and magnetometer) which allowed, on the one hand,

to adjust and validate the performance of the algorithms described, and on the other hand, to define the exact number of sensors required and their adequate arrangement.

Once this point was reached, tests were carried out in a real environment, where very promising results were obtained from the use of the system both at intersections and roundabouts, with a very low error rate.

4 Conclusions and future work

Based on the previous works, the following conclusions are obtained:

- Useful and minimally invasive tool for traffic management.
- System capable of generating origin-destination matrices automatically and continuously.
- Economic, simple and easy system to install at roundabouts and intersections.

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