Characterizing the Driving Style Behavior using Artificial Intelligence Techniques

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***Abstract*—The On Board Diagnosis (OBD-II) standard allows accessing the vehicles' Electronic Control Unit (ECU) easily through a Bluetooth OBD-II connector. This paper presents the DrivingStyles architecture, which adopts *data mining* techniques and *neural networks* to analyze and generate a classification of driving styles by analysing the characteristics of the driver along the route followed. The final goal is to assist drivers at correcting the bad habits in their driving behavior, while offering helpful tips to improve fuel economy. Since it is well known that smart driving can lead to a lower fuel consumption, the environmental impact is also reduced. A study involving more than 180 users is being carried out, where their real time traces (with different traffic conditions) is sent periodically to the platform. DrivingStyles is currently available on the Google Play Store platform for free download, and has achieved more than 2800 downloads from different countries in just a few months.**

***Index Terms*—Driving styles; Android smartphone; OBD-II; Neural Networks; Eco-driving; Wireless Network.**

I. Scope and significance of the project

The On Board Diagnostics (OBD-II) [1], [2] standard, available since 1994, has recently become an enabling technology for in-vehicle applications due to the appearance of Bluetooth OBD-II connectors [3]. These connectors enable a transparent connectivity between the mobile device and the vehicle's Electronic Control Unit (ECU).

Using data such as speed, acceleration, and revolutions per minute of the engine, we have implemented a novel solution based on neural networks, which is able to characterize the type of road on which the vehicle is circulating, as well as the driving style of each user. Currently, this information is being collected and used in applications aimed at improving road safety and to promote eco-driving [4], [5], thus reducing fuel consumption and greenhouse gas emissions.

The equipment necessary to complete the demonstration consists firstly of a mobile device, which could well be a smartphone or tablet with Android OS, secondly of a bluetooth electronic device which enables a transparent connectivity between the mobile device and the vehicles Electronic Control Unit (ECU), and thirdly of a vehicle with OBDII connector. However, the demonstration can be done with just the mobile device and an Internet connection to access the data center using a web interface.

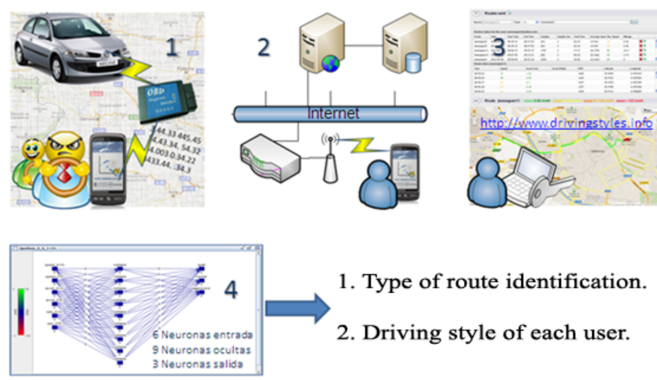

Figure 1. Architecture Overview DrivingStyles.

II. DrivingStyles Architecture

The proposed architecture applies data mining techniques to generate a classification of the driving styles of users based on the analysis of their mobility traces. Such classification is generated taking into consideration the characteristics of each route, such as whether it is urban, suburban or highway.

The system is structured around the following four elements:

1) An application for Android based smartphones. Using an OBD-II Bluetooth interface, the application collects information such as speed, acceleration, engine revolutions per minute, throttle position, consumption, and the vehicle's geographic position.
2) A data center with a web interface able to collect large data sets sent by different users concurrently, and to graphically display a summary of the most relevant results.
3) A neural network, which must be trained using the most representative route traces in order to correctly identify, for each path segment, the driving style of the user, as well as identify the segment profile: urban, suburban or highway.
4) Integration of the tuned neural networks in the data center platform. The goal is to use neural networks to dynamically and automatically analyze user data, allowing users to find out their profiles as a driver, and

thus promoting a less agressive and more ecological driving.

Figure 1 graphically shows the steps followed by users of the DrivingStyles platform to assess their driving styles. The first step is registering the user at http://www.drivingstyles.info, downloading the free Android application.

III. Android Application

The Android application (see figure 2) is a key element of the system, proving connectivity to the vehicle and to the DrivingStyles web platform. Currently, it can be downloaded for free from the DrivingStyles website http://www.drivingstyles.info, or from Google Play *https://play.google.com/store/apps/details?id=com.driving.styles*.

A. Main Module

The main module of our application launches the background processes responsible for capturing data sent by the OBD-II and the GPS interfaces, as well as the phone's accelerometer (see figure 3).

B. Route Upload Module, Map and Graphical Information

The route upload module is in charge of sending the users' traces to the website data center for further analysis. The information screen displays the header information of the selected route such as: date of the captured data, start time, finish time, fuel economy, and maximum speed.

The map module and the graphical information modules are in charge of displaying information relevant to the user in the most convenient manner. The graphs can be displayed in real-time or by selecting data from previously stored paths.

We have chosen acceleration, the speed, and the revolutions per minute (rpm) parameters because they are the most relevant ones, and are also the ones we have selected for training our neural network (see figure 4).

The map module allows displaying the GPS position on the map. GPS coordinates are drawn using the Google Maps APIs.

Figure 2. Snapshots of the home screen and the application running on a vehicle.

Figure 3. Snapshots of the main screen and the data sending module.

Figure 4. Snapshots of the acceleration, speed, rpm, and fuel comsumption.

The path is shown by using different colors depending on the vehicle's speed.

IV. DrivingStyles Web Interface

The second main component of our architecture corresponds to the data center and its web interface. The URL of this module is http://www.drivingstyles.info.

Basically the data center provides functionality to work with User, Routes and Statitics.

A. Routes

In the Routes' section, the users can access all the routes they have uploaded. The selected route is shown in a map. The path varies its colour depending on the speed of the car, see figure 5.

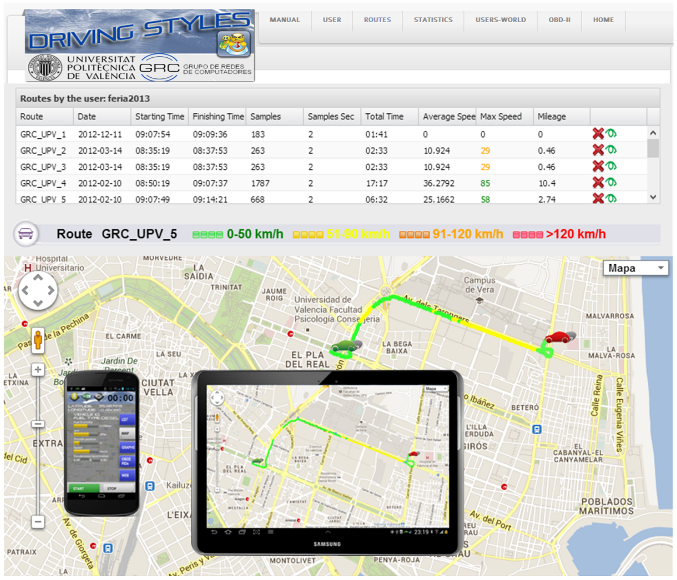

Figure 5. Snapshot of a route map.

B. Statistics

In addition, the last two graphs show the results that the neural network sends back, including the driving styles (see figure 6) and the route characteristics. Next we provide detailed information about the neural network we proposed for characterizing driver styles.

V. Neural Networks based data analysis

After studying the different types of algorithms available, we decide to choose backpropagation [8] since this kind of algorithm provides very good results in classification problems.

After considering the many variables that can be obtained from the Electronic Control Unit (ECU), we have chosen to train the neural network using: a) the mean and standard deviation of speed, b) the vehicle acceleration, and c) the rpm. In all vehicles used for testing, these variables were easily obtained.

The results obtained from real data can be seen in figure 6, retrieved from the website data center. They refer to the neural network output that determines the behavior on that route.

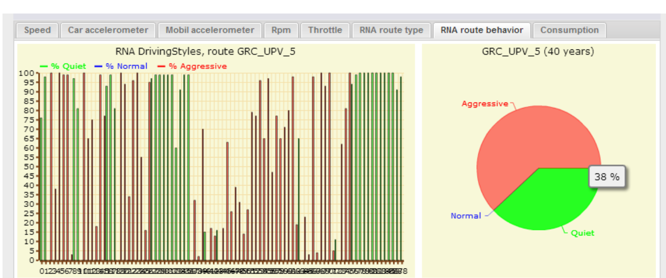

Figure 6. Route behavior.

VI. Conclusions and future work

This demo proposal presents the DrivingStyles platform, which integrates mobile devices with data obtained from Electronic Control Units (ECU) to determine the type of road where the driver is circulating, as well as his driving habits, helping to promote a more ecological driving style by making drivers more conscious of their behavior on the road. Our platform also offers helpful tips to get better fuel economy, reducing fuel consumption with the consequent impact on the environment. We implemented this platform using real devices, and the results we obtained based on real user traces are quite encouraging, showing that the classification of both routes and driving styles using neural networks presents a high correlation with the actual routes and driver behavior.

The application, which is available as a free download in the DrivingStyle's website and in the Google Play Store, has achieved more than 2800 downloads from different countries in just a few months.

As future work, we intend to extend this platform to provide traffic recommendations based on real-time feedback about the congestion of different routes. We are also working on the inclusion of two new parameters in addition to the three variables previously introduced to the artificial intelligence algorithm: the fuel consumption and the brake position; we believe the latter ones are also closely related with the driving behavior.

Acknowledgments

This work was partially supported by the Ministerio de Ciencia e Innovación, Spain, under Grant TIN2011-27543-C03-01, and by the Universitat Politècnica de València through the ABATIS project (PAID-05-12).

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