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Alcohol consumption detection through behavioural analysis using intelligent systems

Audrey Robinel *, Didier Puzenat

Laboratoire LAMIA, Université Antilles Guyane Campus de Fouillole, BP 250, Pointe-a-Pitre, 97175 Grande-Terre, Guadeloupe

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ABSTRACT

We describe in this paper a new methodology for blood alcohol content (BAC) estimation of a subject. Rather than using external devices to determine the BAC value of a subject, we perform a behaviour analysis of this subject using intelligent systems. We monitor the user's actions in an ordinary task and label those data to various measured BAC values. The obtained data-set is then used to train learning systems to detect alcoholic consumption and perform BAC estimation. We obtain good results on a mono-user base, and lower results with multiple users. We improve the results by combining multiple classifiers and regression algorithms.

1. Introduction

1.1. Detection of alcohol

Alcohol impairs driving skills by diminishing the field of view, lowering the reaction time and also some inhibitions. The consequences are that the driver is less aware of his environment, but also more prone to dangerous behaviours while having a lower ability to react quickly and efficiently to an event. The combination of those alterations make it so that a drunk driver is very likely to cause an accident. Depending on the country, there is a fixed threshold of blood alcohol content (BAC) over which it is considered dangerous to drive, and thus it is forbidden. BAC measurement techniques have been developed early with the multiplication of automobiles (Bogen, 1927). For this purpose law enforcement often use high end breathalyzers based on spectroscopy to determine the amount of alcohol in the air expelled from a subject. However, those devices are very expensive (in an order of thousands of euros). For this reason, ordinary drivers use either a single use chemical test, that indicates a threshold exceeding, or a electronic device that gives a measurement of the BAC. In the first case, many tests are unreliable, and some would not resist to the temperature conditions met in a car (either too hot in the sun, or too cold during the winter). In the second case, electronic breathalyzer accuracy vary greatly from one device to another. Many devices sold as electronic breathalyzer are in fact "toys" that are unreliable and inaccurate. Many good consumer class breathalyzers cost more than 100 euros. Few people are likely to pay this much. Furthermore, those devices require calibration, or sensor replacement after a fixed number of uses. If not used properly, a breathalyzer may provide false readings, and even be damaged. At last there is fundamental problem with this approach: a drunk person is likely to forger about testing himself, or to believe being sober enough to drive, due to the loss of inhibitions and judgement impairment caused by the alcohol.

Our approach is to perform a BAC estimation without requiring any action from the user. We thus monitor the user behaviour in the car, using readily available sensors, and process the collected data to provide a BAC estimation of the driver. Similar methodology have been used for driver inattention detection using a camera (D'Oratio, Leo, Guaragnella, & Distante, 2007), or using the in car sensors (Torkkola, Massey, & Wood, 2004). The visual approach is the most used in this problematic, with multiple IR cameras (Qiang & Xiaojie, 2002) or a single one (D'Oratio et al., 2007; Bergasa, Nuevo, Sotelo, Barea, & Lopez, 2006) and it is also used for the detection of drowsiness (Grace & Steward, 2011).

Image processing algorithms have high accuracy in good conditions, but can have difficulties in bright environment, or for people with glasses (Bergasa et al., 2006). Anyway, the visual approach mostly relies on the detection of the pupils of the driver, and then on the measure of the PERCLOS (PERcentage of CLOSure of the eyes), which fits the problematic of tiredness, or attention, but may not fit other problematic, such as BAC estimation. These are some of the reasons that motivated our decision to rely only on the sensors that are already available in a real car. For that purpose, the device has to be able to gather data about the user, and process it to extract meaningful information about him. This is the general approach that we propose in this paper. We decided to try to collect data without altering in any way the user's behaviour. To do so, the device must be instrumented so that normal user actions

* Corresponding author.
E-mail addresses: arobinel@univ-ag.fr (A. Robinel), dpuzenat@univ-ag.fr (D. Puzenat).

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can be measured by the device itself. We will gain user information using only these data. Those low level data will be processed in order to extract meaningful information about the driver.

1.2. Plan

We developed multiple prototypes based on this methodology over the years. We will present in Section 1.3 the general context of those experiments, as we are not focused only on driving behaviour, but on human behaviour in general. We will then present the evolution of the driving prototypes, from the first one based on a racing game to the realistic prototype based on a driving simulator that we use as of today.

1.3. Global context

The present work takes place in a larger set of experiments, aimed at instrumenting generic interfaces. A generic methodology was defined in Puzenat and Verlut (2010). It was first applied to a set of child games adapted for touch-screens (see Fig. 1, left) and used to predict mental age of the player. An experiment on a simple racing game was conducted with a similar methodology. We explored with those serious gaming experiments the possibility of using artificial neural networks (ANN) to estimate a value related to the player. We improved the "SuperTuxKart" (see Fig. 1, right) prototype in order to conduct an experiment on blood alcohol content. SuperTuxKart is a simple racing game and it was controlled by the subjects using a basic steering wheel. The controls were very simple, and we could monitor only a few low level data. However, using this simple environment, with an ANN -more precisely a Multi Layer Perceptron (MLP)- we could detect if the subject was drunk (over $0.4\,\mathrm{g\,l^{-1}}$) or not, after only one minute of playing, and even estimate the BAC value. We detailed the results in Robinel and Puzenat (2011).

With promising results with the game, we tried to use a realistic car simulator (see Fig. 2), rather than a game. The environment was much more complex, and the driving skills required were close to those of a real car. Instrumentation also became much more complex, as we could in this context monitor much more low level data, with a greater accuracy. We kept using our ANN, and we managed to detect drunkenness, and also estimate the driver's blood alcohol content value, in Robinel and Puzenat (2012). We kept improving our prototype, and used a larger training base to perform BAC estimation on a single user in Robinel and Puzenat (2013), using the ANN and also Support Vector Machines (SVM). Later on, we proceeded with multi user experimentation with both SVM and ANN. We presented our results for both drunk/sober classification and BAC estimation in Robinel and Puzenat (2013). We obtained lower results in multi-user context, but we could present good results in classification.

We will present here the latest evolution of our prototype, using combinations of classifiers to improve the prediction accuracy.

2. Instrumentation of a device

2.1. Instrumentation: definition

The definition of the Merriam-Webster dictionary for instrument is "to equip with instruments especially for measuring and recording data". In our context, we perform the same tasks, but instead of adding instruments on a real device, we add code in the source code of the driving program (be it a racing game or a realistic car simulator) in order to measure parameters, and record those gathered data. When we will use a real car, we may add physical instruments, or use those readily available in the car. In a simulated environment, we collect and record all the accessible low level data at the maximum possible rate.

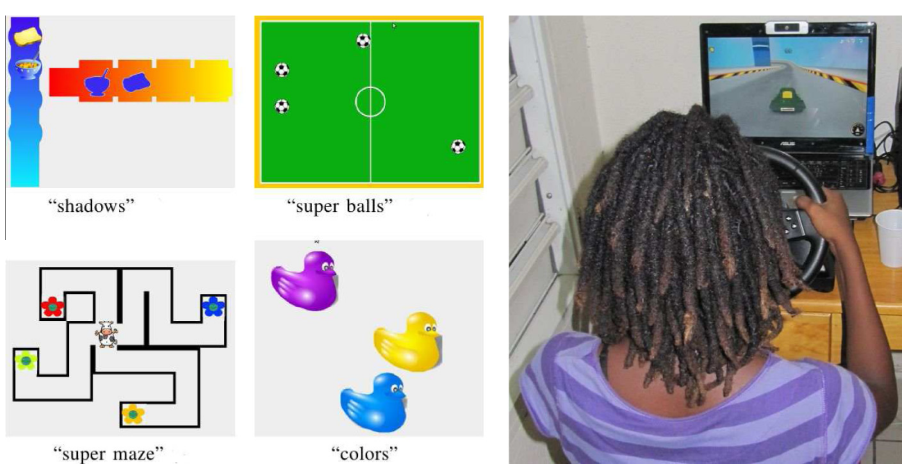

Fig. 1. 4 of the 12 games of the tactile games experiment on the left, and the SuperTuxKart prototype on the right.

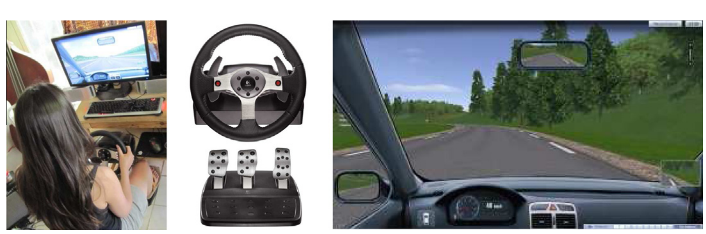

Fig. 2. The realistic prototype setup (left), the used input device used (middle) and a screen-shot of the simulator (right).