Electronic Letters on Computer Vision and Image Analysis 16(2):25-28, 2017

Facial attributes recognition using computer vision to detect drowsiness and distraction in drivers

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Date and location of Ph.D. thesis defense: 30th May 2017, University of Oviedo, Spain

Received 28th Jul 2017; accepted 20th Nov 2017

Abstract

According to the most recent studies published by the World Health Organization (WHO) in 2013, it is estimated that 1.25 million people die as a result of traffic crashes. Many of them are caused by what it is known as inattention, whose main contributing factors are both distraction and drowsiness. Overall, it is estimated that inattention causes between 25% and 75% of the crashes and near-crashes. That is why this is a thoroughly studied field by the research community. The solutions to combat distraction and drowsiness, in particular, and inattention, in general, can be classified into three main categories, where computer vision has clearly become a non-obtrusive effective tool for the detection of both distraction and drowsiness.

The reason for this Ph.D. thesis is the direct consequences of the abovementioned figures and its purpose is to provide mechanisms to help reduce driver inattention effects using computer vision techniques. More specifically, the aim of this thesis is to propose, build and validate an architecture based on the analysis of visual characteristics by using computer vision techniques and machine learning to detect both distraction and drowsiness in drivers. This architecture is designed to operate in vehicular environments, with a very low computational load and easily embeddable into devices with reduced computational capacities in order to deal with images in the different conditions prevailing in this type of environments. The proposed control system integrates several innovative elements in order to operate in a completely autonomous way for the robust detection of the main visual indicators characterizing the driver‘s both distraction and drowsiness.

The architecture has been validated, firstly, with reference databases testing the different modules that compose it, and, secondly, with users in real environments, obtaining in both cases, promising results with a suitable computational load for the embedded devices in vehicle environments.

1 Introduction

Driving is an activity that requires a high degree of concentration on the part of the person who performs it, since the slightest negligence is sufficient to provoke an accident with the consequent material and/or human

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Recommended for acceptance by Anjan Dutta and Carles Sánchez
http://dx.doi.org/10.5565/rev/elcvia.1134
ELCVIA ISSN:1577-5097
Published by Computer Vision Center / Universitat Autònoma de Barcelona, Barcelona, Spain

losses. According to the most recent study published by the World Health Organization (WHO) in 2013, it was estimated that 1.25 million people died as a result of traffic accidents, whereas between 20 and 50 million did not die but consequences resulted in chronic conditions. All these deaths and accidents not only have a direct impact on victims and families, but they also mean a high cost for government budgets, estimated at between 3% and 5% of their Gross Domestic Product (GDP). Many of these accidents are caused by what is known as inattention. This term encloses different conditions such as distraction and drowsiness, which are, precisely, the ones that cause more fatalities.

Many publications and research have tried to set figures indicating the consequences of inattention (and its subtypes), but there is no exact number of the accidents caused by inattention since all these studies have been carried out in different places, different time frames and, therefore, under different conditions. Overall, it has been estimated that inattention causes between 25% and 75% of accidents and near-accidents. A study on drowsiness while driving in ten European countries found that fatigue risks increasing reaction time by 86% and it is the fourth leading cause of death on Spanish roads. In addition, it is noted that 75% of Spanish drivers have suffered episodes of sleepiness while driving, a much higher percentage than the average of 47% who admitted this fact. In addition, another important factor to consider is that, although accidents caused by drowsiness are usually very serious (having regard to the abovementioned fatal statistics), many drivers underestimate this situation and drive even if they notice the presence of symptoms. Frequent yawning, pitching movements, blurred vision, drooping upper eyelids and efforts to keep both attention and eyes open are common signs of drowsiness. Distraction is also a major contributor to fatal accidents in Spain. According to the Directorate General of Traffic (DGT), distraction is the first violation found in fatal accidents, 13.15% of the cases. Overall, considering both distraction and drowsiness, the latest statistics on inattentive driving in Spanish drivers are alarming, appearing as the leading cause of fatalities (36%), well above excessive speed (21%) or alcohol consumption (11%).

2 Motivation

Because of these figures and their consequences, inattention has become a widely studied field by the research community, whose studies and solutions to combat distraction and sleepiness, in particular, and inattention, in general, can be divided into three broad groups:

- Methods based on the analysis of the behavior of the vehicle.
- Methods based on the analysis of the driver's physiological variables captured by different sensors.
- Methods based on the analysis of the driver's visual characteristics by capturing images using computer vision methods.

The methods based on the analysis of the driver's visual characteristics by capturing images using computer vision methods, which, for their non-intrusive and effective characteristics, have become a leading way to detect both distraction and drowsiness. That is why this is a thoroughly studied field by the research community, where solutions to combat distraction and drowsiness, in particular, and inattention, in general, can be classified into three main categories, and, where computer vision has clearly become a non-obtrusive effective tool for the detection of both distraction and drowsiness. That is why this is a thoroughly studied field by the research community, where computer vision has clearly become a non-obtrusive effective tool for the detection of both distraction and drowsiness. The reason for this Ph.D. thesis is the direct consequences of the abovementioned figures and its purpose is to provide mechanisms to help reduce driver inattention effects using computer vision techniques.

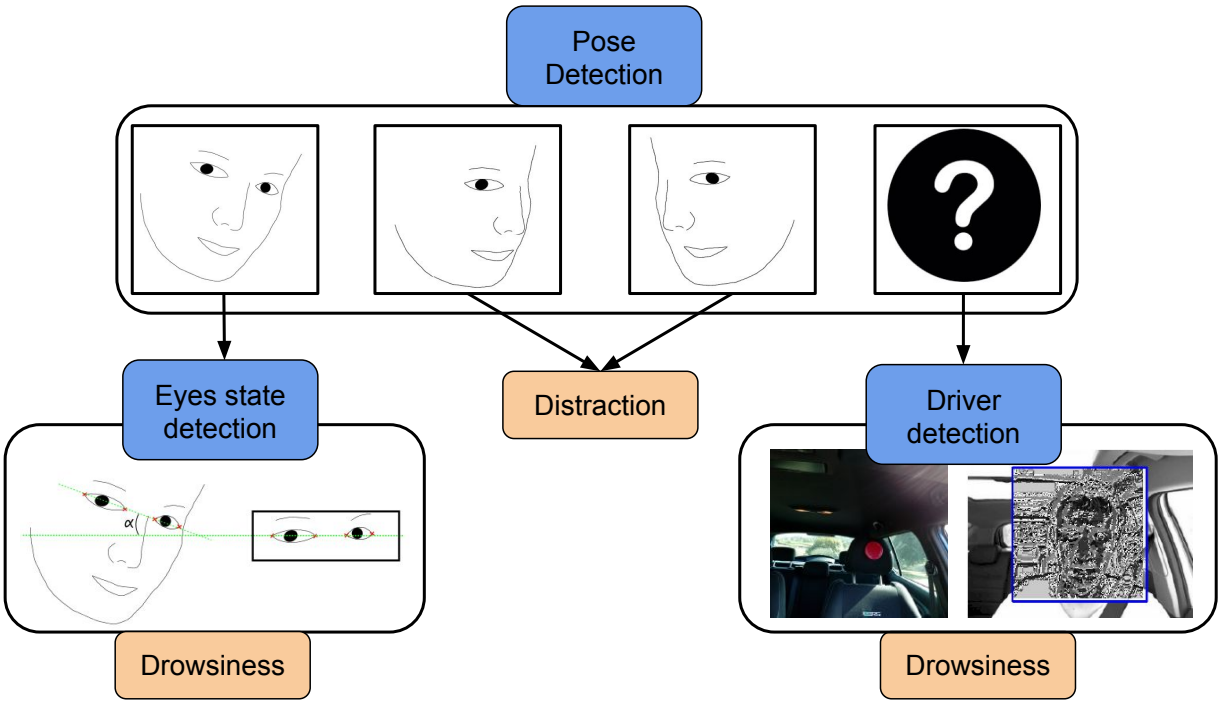

Figure 1: Proposed architecture to detect both distraction and drowsiness in drivers.

3 Contributions

The extraction of facial attributes can be used to detect inattention robustly. Specifically, research establishes a frame of reference to characterize distraction in drivers in order to provide solid foundations for future research [1]. Based on this research [1], an architecture based on the analysis of visual characteristics has been proposed, constructed and validated by using techniques of computer vision and automatic learning for the detection of both distraction and drowsiness [2], integrating several innovative elements in order to operate in a completely autonomous way for the robust detection of the main visual indicators characterizing the driver's both distraction and drowsiness:

1. A review of the role of computer vision technology applied to the development of monitoring systems to detect distraction [3].

2. A face processing algorithm based on Local Binary Patterns (LBP) and Support Vector Machine (SVM) to detect facial attributes [4].

3. Detection unit for the presence/absence of the driver using both a marker and a machine learning algorithm [2].

4. Robust face tracking algorithm based on both the position of the camera and the face detection algorithm [2].

5. A face alignment and normalization algorithm to improve the eyes state detection [3].

6. Driver drowsiness detection based on the eyes state detection over time [2].

7. Driver distraction detection based on the position of the head over time [2].

4 Method and results

The proposed architecture can be seen in Figure 1. This architecture has been validated, firstly, with reference databases testing the different modules that compose it, and, secondly, with users in real environments, obtaining in both cases, excellent results with a suitable computational load for the embedded devices in vehicle environments [2]. In connection with the tests performed in real-world settings, 16 drivers were involved performing several activities imitating different signs of sleepiness and distraction. Overall, an accuracy of 93.11% is obtained considering all activities and all drivers [2].

A more in depth explanation about the proposed method and results can be seen in the online link of this Ph.D. thesis (www.atc.uniovi.es/rusamentiaga/Alberto/PhD.pdf).

5 Conclusions and future work

An architecture based on the analysis of visual characteristics by using computer vision techniques and machine learning to detect both distraction and drowsiness in drivers was proposed, built and validated. Additionally, other contributions of this thesis have been experimentally validated in controlled settings, but are expected to be included in the abovementioned architecture: (1) glasses detection algorithm prior to the detection of the eyes state [3] (the eyes state can not be accurately obtained if the driver is wearing glasses or sunglasses [1]); (2) face recognition and spoofing detection algorithm to identify the driver [5]; (3) physiological information (Heart Rate, Respiration Rate and Heart Rate Variability) are extracted from the users face [6] (using this information, cognitive load and stress can be obtained [1]); (4) a real-time big data architecture to process a large number of relatively small-sized images [7]. Therefore, future work will include these points to complete the architecture.

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