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ALGORITHM FOR SHAKE DETECTION IN VIDEOS FOR ADVANCED DRIVER ASSISTANCE SYSTEMS

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ABSTRACT

The aim of this research is to develop a computer vision algorithm for the detection of blurred images caused by the shaking of the camera in an Advanced Driver Assistance System (ADAS). Cameras on board of cars, as part of ADAS, are used to detect various scenarios such as impeding forward collision, pedestrian detection, traffic sign detection, traffic light detection, etc. In case of bumpy roads the user needs to be informed that the system cannot provide accurate warning as the video cannot be used. Also, in case of computer vision based ADAS features running on tablets or smart phones, the user needs to be informed that they will no longer be able to use the ADAS. The acquired images are processed with the proposed algorithm in order to assess if shaking was detected in online video.

KEYWORDS: shake detection, advanced driver assistance systems

1. INTRODUCTION

Worldwide automotive industry is aiming at designing cars in such a manner so as to minimize accident casualities [1]. In this sense, Advanced Driver Assistance Systems (ADAS) have become an important feature of modern cars to improve traffic safety. ADAS systems use a wide range of sensors (Camera, Radar, Ultrasonic) to capture information about the environment in which the car is moving and then process this information to implement the ADAS functionalities[2], [3]. These are related to forward collision warning system (which aims to inform or even break when an impending collision is detected), pedestrian detection (which refers to detecting pedestrians in the street area and inform de driver about it), traffic sign detection (which means detecting traffic signs by use of camera and informing the driver about it), lane detection, drowsiness driver detection, blind spot car detection, and the list may continue. Different car manufacturers refer to the some type of ADAS feature using a different acronym or name. Many of the ADAS features are based on a camera mounted behind the rearview mirror, providing the "eyes" to these systems. Computer vision is an relative new discipline and is aim is to emulate visual ability of humans by intermediary of a computer. This is a interdisciplinary field using knowledge from algebra, geometry, physics to provide methods for analysing and understanding images and consequently videos.

Real time computer vision applications as those included in ADAS system have stringent performance requirements. Moreover nowadays ADAS systems include several computer vision algorithm for different purposes (detecting traffic signs, detecting pedestrians, etc) and all must share most of the time the some processor. The restriction of relativelly low resources impose a strict processor resources restriction when developing computer vision application for ADAS. In case of a bumpy road, the image is not appropriate to be used and the driver must be informed that the ADAS system cannot be trusted. Also, in case of computer vision based ADAS features running on tablets or smart phones, the user needs to be informed that they will no longer be able to use the ADAS. There are many researchers that have taken interest in image stabilisation and motion detection [4], [5], [6], [7], [8], [9]. In the past few years also many performance evaluation methods and derived video stabilization algorithm have been developed [10][11]. Among shake detection methods are background subtraction algorithms, as they provide ease of use. However, waving leteral objects such as trees, buildings at relativelly high speed (up to 70 km/h) are causing serious problems to use background subtraction model to determine relative shaking of camera. Moreover, a successful background subtraction method needs to determine background as accurate as possible. The requirements of an ADAS system add extra complexity to the problem and therefore make this method inapproriate for a real-time detection at high speeds. Optical flow detection algorithm is a suitable method in this case as can detect the moving objects.

However, the ADAS system is supposed to detect mainly vertical shake, (besides horizontal shakes an d rotation) in specific conditions. The objective of this research is to develop a computer vision algorithm for the detection of blurred images caused by the shaking of the camera in an Advanced Driver Assistance System (ADAS). The acquired images are processed with the proposed algorithm in order to assess if shaking was detected in online video. The present paper presents results on a number of different real sequences.

2. EXPERIMENTAL PROCEDURE

When a frame is taken in conditions of a fast moving object, motion blur can cause significant degradation of the image. This is caused by the movement of the scene relative to the camera. Both object moving and camera shaking contribute to this blurring. We address the problem of detection of blurred images caused by vertical shaking in a video stream obtained from a camera mounted on a moving car to be used for ADAS system. The proposed method relies on feature detection and on optical flow detection which allows obtaining a dynamic template of each frame by enforcing their temporal coherence. This algorithm, which considers only vertical shaking, allows us to characterize movement trajectories. The characterization of the vertical fast movement of the image will allow further development of algorithms for image stabilization.

There are several scenarios that might introduce false results, such as partial occlusions, stop and go motion, other cars moving with different speed or in different directions, lateral movement, and change of direction. We have mounted a camera on the rear mirror of a car and took several dozens of hours of traffic. We also used specific road peculiarity films from other free sources.

Our algorithm takes into account the flow motion vectors depicted with green lines. The more motion detected, the greater the length of the vector represented by the line. Several situations have been identified. In Fig.1 we noted the relative tilt of the vector for the case when the car is going straight.

Fig. 1. *Vector motion as identified by the flow motion detector*

Fig.2 shows a different scenario, when the car has low speed (under 20 km/h) and another car is moving laterally. The vector tilt will be horizontal.

Fig. 2. *Vector motion as identified by the flow motion detector in case of lateral movement*

Also, there are cases such when the car is changing direction at a cross intersection.

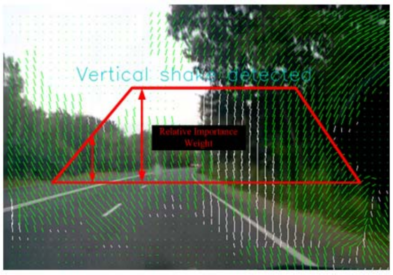

Fig. 3. *Definition of image area considered and the Relative Weight for motion vector value*

The computational cost of flow detection is high and introduces further restrictions concerning computational resources and makes it very difficult to be applied in a real-time system.This approach, using motion detection, is quite vulnerable to such limitations. However, our algorithm use only a specific region.

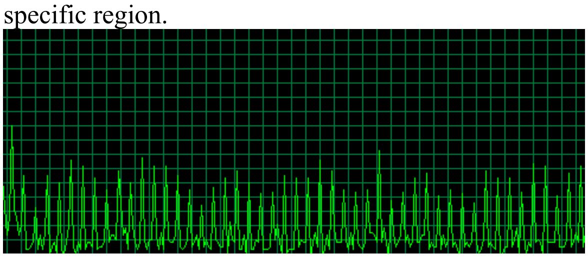

Fig. 4. *Processor loading during runing the application for shake detection*

As seen in Fig.4 the processor loading allows an important amount of further loading by other processes, as necessary in case of development of ADAS systems. The proposed algorithm is just a complementary feature of intelligent system to assist driver, besides other main features such as sign detection, forward collision detection and so forth. According to the algorithm, only the movement vectors in the trapezoidal area indicated by the red line are considered. We want to stress specific situations when the motion vector has a different orientation. In these cases the algorithm should not provide false positive response. According to the algorithm, Relative Importance Weight is defined.

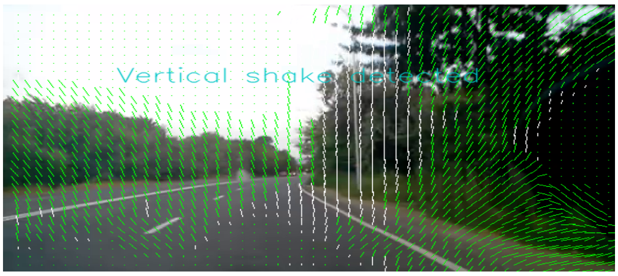

Fig. 5. *Detection of image shaking*

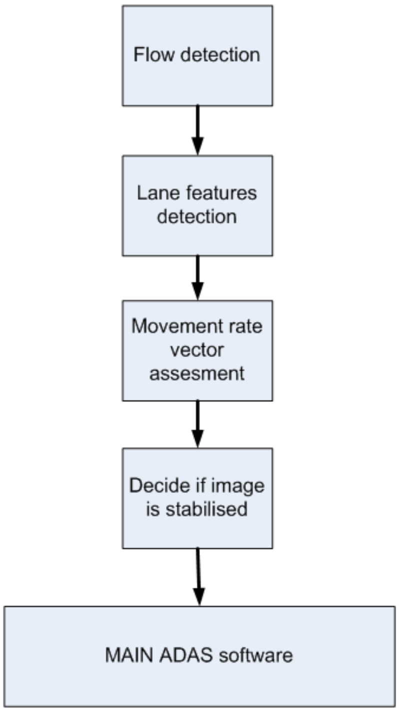

Fig. 6. *Algorithm for shake detection*

Relative Weight, which represents the contribution to the total index of the movement vector in the trapezoidal area, has different values in such a way that the movement in the center of the image weighs more than the movement on the left and right sides.

Fig. 7. *Detection of lane markings*

I aim to extract the camera motion information taking into account the main path determined by lane markings, if such information is available. As depicted in Fig.7 only detection of lane markings are shown according to the algorithm described in Fig.8. In case there are no lane markings, I used a very simple method that is to compare the shaking with the main path previously determinated taking into account last 100 frames, considered as original stable camera motion. In such a manner I defined the optimal camera path was defined for the two scenarios, in case the lane marking are detected and respectivelly, in case no lane markings could not be detected.

Such an approach based on simple euristics principles resulted in good performance. However, it is reasonable to consider that most of the roads have lane markings and the optimal camera path is determined using the lane marking detections. The relationship between the original path and optimal path is determined further using movement rate vector assesment.

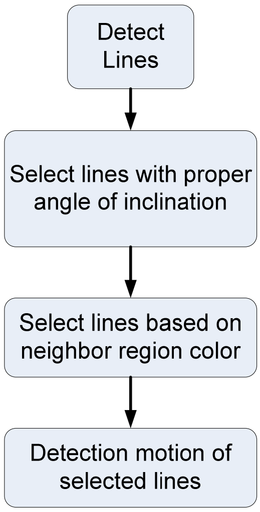

Fig. 8. *Algorithm for detection of lane markings*

Unwanted camera motion is modeled using several parameters to characterize shaking:

1) Direction which indicates which direction has the relative shaking for the last 500 frames, described by value in both horizontal and vertical directions.

2) Amplitude which shows whether the shaking could be compensated eventually by an anti-shaking algorithm, in a future development and further development of the present algorithm described in this apper. When the shaking is important there is no change of compensating the motion, such as in case of a shaking tablet installed in a car running of rough terrain.

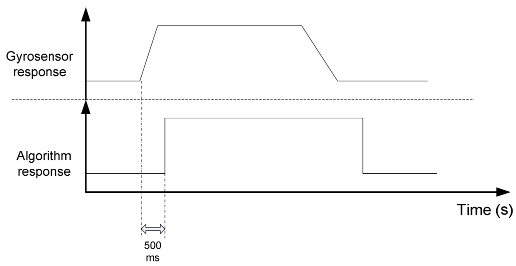

Fig. 9. *Response comparison between proposed algorithm and gyrosensor*

3) Movement type which shows whether there is scale and rotation changes in consecutive images in the video stream collected from camera installed, as part of ADAS system.

With white color is marked the vertical or near vertical orientation of the vector movement. The algorithm is presented in Fig. 6. Several steps are required to determine if the image is shaken vertically. Firstly, the optical flow is determined with Gunner Farneback's algorithm, than lane features are detected as the centre line of the street. The third step is the movement rate vector assessment where the trapezoidal area is considered and the Relative Importance Weight is calculated.

Concerning algorithm response time I mounted a gyroscope-accelerometer on the tablet aquiring live video in order to make a comparison between proposed algorithm and gyrosensor response. Though any gyroscope has its own errors it will provide a faster response in time than a computer vision algorithm. I used as hardware setup a device IMU Analog Combo Board Razor with 6 degree of freedom connected to an Atmel Avr development card which stored the relative time of vertical shake detection. The average response difference between gyroscope and the algorithm was 500 ms (see Fig.9). I can conclude the time response it is good and the algorithm can be used in ADAS systems. However the algorithm response in this phase of development cannot be used or adapted for designing an algorithm for image stabilization, in order to compensate camera shaking. The detection of shaking may last even seconds, enough for ADAS to inform the driver the system cannot further assist the driver or, the information to be used by another algorithm to compensate shaking. The decision if the frame is forward to the main program of ADAS system. The program requires low computational resources and works on different resolutions. I implemented the setup on a laptop with i3 Core i3-350M. The processor and the processing time for a 800x600 is about 18 ms. The algorithm supposes that a video stream cannot be trusted for ADAS if vertical shake is detected for a period of 5 s. The algorithm has been tested for about 20 hours of video streaming and it showed no false positive response.

3. CONCLUSIONS

Based on consecutive frame analysis, region image motion detection and lane marking main movement detection we propose a method for shake detection in complex traffic monitoring systems such as ADAS, which is proved to be efficient, accurate and robust.

The main advantage of the proposed algorithm is that it requires low processing resources and therefore is suitable for use in real-time applications as ADAS. In addition, detection of main camera path taking into account lane markings translates into the fact the developed algorithm is quite robust to traffic scenarios. Tests on the real traffic video using a camera installed in a car demonstrate that it has a good performance. The algorithm described in this paper allows shake detection of video stream on an ADAS system with high accuracy. The characterisation of the vertical fast movement of an image will allow further development of algorithms for image stabilisation.

A future development of the proposed algorithm might include building an algorithm for content stabilization of shaking videos designed for ADAS system, taking into account specific requirments.

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