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EXTENDED ABSTRACTS

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Preface

The concept of CAST as Computer Aided Systems Theory was introduced by F. Pichler in the late 80's to encompass those computer theoretical and practical developments as tools for problems in System Science. It was thought as the third component (the other two being CAD and CAM) that will provide for a complete picture of the path from Computer and Systems Sciences to practical developments in Science and Engineering.

Franz Pichler, of the University of Linz, organized the first CAST workshop in April 1988, which demonstrated the acceptance of the concepts by the scientific and technical community. Next, the University of Las Palmas de Gran Canaria joined the University of Linz to organize the first international meeting on CAST, (Las Palmas February 1989), under the name EUROCAST'89 and proved to be a very successful gathering of systems theorists, computer scientists and engineers from most of European countries, North America and Japan.

It was agreed that EUROCAST international conferences would be organized every two years, alternating between Las Palmas de Gran Canaria and a continental Europe location, being later decided to celebrate them in Las Palmas. Thus, successive EUROCAST meetings took place in Krems (1991), Las Palmas (1993), Innsbruck (1995), Las Palmas (1997), Vienna (1999), Las Palmas (2001), Las Palmas (2003) and Las Palmas (2005), in addition to an extra-European CAST Conference in Ottawa in 1994. Selected papers from those meetings were published by Springer-Verlag Lecture Notes in Computer Science nos. 410, 585. 763,1030, 1333, 1798, 2178, 2809, and 3643 and in several special issues of Cybernetics and Systems: an International Journal. EUROCAST and CAST meetings are definitely consolidated, as it is shown by the number and quality of the contributions over the years.

EUROCAST 2007, to be held in the Elder Museum of Science and Technology of Las Palmas, February 12-16, continues with the approach tested in last Conferences as an International computer related Conference with a true interdisciplinary character. There are different specialized Workshops which, in this occasion, are devoted to 1.-Systems Theory and Simulation, chaired by Pichler (Linz) and Moreno Diaz (Las Palmas); 2.-Computation and Simulation in Modelling Biological Systems, chaired by Ricciardi (Napoli); 3.-Intelligent Information Processing, chaired by Freire (A Coruña); 4.-Computers in Education, chaired by Martín-Rubio (Murcia); 5.-Grid Computing, chaired by Volkert (Linz); 6.-Applied Formal Verification, chaired by Biere (Linz); 7.-Cellular Automata, chaired by Vollmart (Karlsruhe); 8.-Computer Vision, chaired by Álvarez (Las Palmas); 9.-Heuristic Problem Solving, chaired by Affenzeller (Hagenberg); 10.-Signal Processing Architectures, chaired by Huemer (Erlangen) and Müller-Wipperfürth (Hagenberg); 11.-Robotics and Robotic Soccer, chaired by Kopacek (Vienna); 12.-Cybercars and Intelligent Vehicles, chaired by Parent (Paris) and García-Rosa (Madrid) and 13.-Artificial Intelligence Components, chaired by Chaczko (Sidney).

XIII. Artificial Intelligent Components

3D Driver Identification In Outdoors Condition Using Stereo Vision

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1 Abstract

This work is intended to get a reliable 3D position of a driver's head in daily outdoors conditions using computer vision in order to develop a smart airbag. We present a new approach, taking foot on a modification of the pre-corners detection technique. We search for the driver's head in the left and right images. After that, we look for correspondence between rich information zones over each image. Then, using epipolar relationships, we get 3D information to feed a spatial filter, to get the most reliable position of the driver's head. Some experimental results and the conclusions are presented.
Keywords: Airbag, Vision Processing, Stereo Vision.

2 Introduction

Reliable dynamical 3D head detection is very important to be able to command an intelligent airbag system because this offers a complete and instantaneous information of the size and position of the driver's head, performing an adaptive inflation to receive the best way that head after a car crash. With the current state of the hardware it is possible to implement such a system in a real time environment with high confidence. Previous developments show a good approach but with a lack of reliability because they are based on lighter processing techniques, i.e. [1] have a problem when the elements under the "ellipse" are not a passanger's head but his/her arm or even another object, because they just get reflectance and detect abscense or not of something into the interest zone. [2] performs a good camera lighting dynamic range study, but the detection algorithm, even under laboratory controlled conditions to emulate sun light is not completly reliable. Our approach, carried on over several car drivers shows a good first approach in a daily environment without using light pass-band filtering, with a static car, but with huge light variation between shadow and light

3 Implementation

Images obtained in outside conditions show an important variation between direct sun light and shadow zones over the driver faces. As consequence algorithms found a deep problem to identify driver's head. Exploring the bibliography [1], [2], [3], [4] and [5], tried to get disparity between images, in a direct form and taking background off the images, but we couldn't get a reliable result because, besides the already detected problems by the authors of these works, we also observe huge problems when the subjects cross the high illuminated zone from the shadow zone. Critical is the fast movement of the driver toward the front, as could occur in a frontal crash. We got lost the driver's head position for a while, and in this crucial situations is not suitable to filter the position with a statistical filter, because of the nature of the impact. We concluded that background subtraction is not reliable for this work, because of the lighting differences. Besides, the lighting conditions may vary since the start of the processing to the end of it.

An other remarked knowledge tip is that the intermediate processing results of the corners algorithm was highly related with our target. Then, we cut the regular flow of processing at this point and add new processing algorithms from this point on. The algorithm arises from: $(D_x)^2 D_{yy} + (D_y)^2 D_{xx} - 2 D_x D_y D_{xy}$, where D_x stands for the first derivative of the image along the "x" direction, etc. This basically is the pre corners algorithm. We get the float image obtained this way and perform a convolution operation with a filter developed to get a good head detection reliability.

We implemented a specialized filter to get the driver's head in our 2D left image. This filter is based on an ellipse of similar size to the driver's head, besides it emphasize the interior zone of the ellipse and penalize the out zone of it, limiting the penalizing zone to a little crown around the ellipse. This filter is convoluted with the pre processed left image and a head center estimated this way. The experimental weights of the convolution filer were determined to get a good detection performance. Further efforts in the automation of this filter weights determination are being developed.

After complete this step, the right image is pre processed in a similar fashion and the driver's head is estimated to be near the epipolar correspondence to the left location associated with a center seat position of the driver. A generous exploring radious is assigned to the right estimation of the head over the right image.

In order to understand the next steps, please think that our final step will be to determine the driver's head position using a 3D filter, then we are going to feed this filter with 3D positions from the epipolar relationship between images and we will try to use only points belonging to the founded head over the left image. Candidate points are selected taking from the left image the pre processed points that are in the 10 per cent highest percentile inside the detected ellipse. A similar approach is taken for the right image over the enlarged ellipse previously mentioned. The criteria is based on the absolute value of the pre pro-

negative derivatives of the images. With this restrictions in mind, we look for correspondence between the left points over the right image and with the formed cloud of points. We get the best match of a 3D revolution ellipsoid exterior surface of similar size of an adult human being against this cloud. This way the 3D position of the center of the head is determined as corresponding to the center of the ellipsoid.
All the algorithms are time optimized. The precorners algorithm is basically the OpenCV provided algorithm cutted at its first stage. The 3D epipolar relationship between images is obtained over a limited number of robust candidates. The ellipsoid distance to the determined 3D points is performed through a pre-calculated surface table, which position and orientation offset is continuously adjusted until determination of the final position, but over a limited number of posibilities.
Besides that, the 2D head's image size depends on the projective relationship. Then, to get a better approach, we added a second filtering using the previous detected head size and position as a starting point for each new search of the head. This approach wasn't absolutely reliable, so we compared on each step this approach merit figure against the first approach merit figure and get the second one only if its merit was good enough. This merit figures are based on a convolution match between previous and actual estimated head detections in the second algorithm and in the convolution output of the first algorithm, weighted by an averaged value to make those quantities comparable.

4 Experimental Results

Images were taken over three volunteers. The experimental conditions were sunny day in the university parking zone. The drivers movements tried to be regular movements besides simulated "crash movents" with relatively fast frontal displacements of their heads. The algorithm shown to be robust enough to follow the volunteer's head with a maximum estimated error of around 10 cm. Besides that, the error distribution was balanced and doesn't depend on head speed. We don't use a statistical filter because we want to get the best performance in a crash condition, then statistical filter stability would be working against our mandatory first goal. This approach is showing a worst performance in head detection under normal conditions, but let us get a best following capability under fast movements, as in crash conditions. The second described algorithm proved to be good enough only in almost static conditions, to give us a better "static detection" performace. But, when the head's direction or position abruptly changes from one image to the next, this algorithm perfomance wasn't reliable, relying on the first described one. We are showing two stereo images

Fig. 1. Correspondence between points on left and right in two situations

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