Efficient real-time algorithms for eye state and head pose tracking in Advanced Driver Support Systems

Riad I. Hammoud, Andrew Wilhelm, Phillip Malawey, and Gerald J. Witt
Delphi Electronics and Safety, Kokomo, IN, USA
Email: riad.hammoud@delphi.com

This demonstration shows cutting-edge computer vision methods employed in advanced vision sensing technologies for medical, safety and security applications, where the human eye represents the object of interest for both the imager and the computer. As the eye scans the environment, or focuses on particular objects in the scene, the processor simultaneously localizes the eye position, tracks its position and movement over time, and infers counter measures such as fatigue level, attention level, and gaze direction in real-time and automaticaly. The focus of this demonstration is placed on four different algorithms:

- Auto-initialization (RHED): one or both eyes will be detected robustly and accurately in real-time, without subject and/or light calibration. This algorithm is also utilized in recovery from tracking. Our experimentations have shown great success using this algorithm on a large population set in different lighting conditions. Figures 1.(a) and 1.(b) show a snapshot of the detection results. The accompanied video shows detection results on subjects of various complexity and in various imaging conditions.

- Eye position tracking (SIRAT): once the auto-initialization is performed, our tracker follows the position of one or both eyes in real-time. The videos will show robust and accurate tracking results on different subjects and various conditions (see figures 1.(c) and 1.(d)). In particular we will show the performance of our tracker on extended closed eye scenarios for subjects with light features (no eyelids when closed) and dark features. More challenging situations are handeled by our tracker and shown in these videos such as "moving head with closed eyes and depth changes", and "occluded eye with glare".

- Eye Closure Recognition (HRA): in each frame the eye state is reported as closed or open with no delay. This is a difficult recognition problem, especially when the subject population is diverse and the spatial image resolution is small. In this video we demonstrate our algorithm on several test subjects with different eye shapes (dark vs. light features, with and without eyeglasses). The individual outputs of this algorihtm are accumulated and then processed to derive fatigue and drowsiness measurements. A snapshot from this video is shown in figures 1.(e) and 1.(f) where "o" refers to open eye state and "c" for closed eye state.

- Driver head pose categorization: the driver pose is classified as frontal vs. non-frontal. The output is accumulated over a period of time and processed to derive driver distraction measurements. Figures 1.(g) and 1.(h) depict some results of this algorithm. The green box refers to frontal driver pose while the red one indicates a non-frontal driver view.

The video contains twelve different test subjects. It is about 4 minutes, in MPEG-2 standard format, at 30 fps.

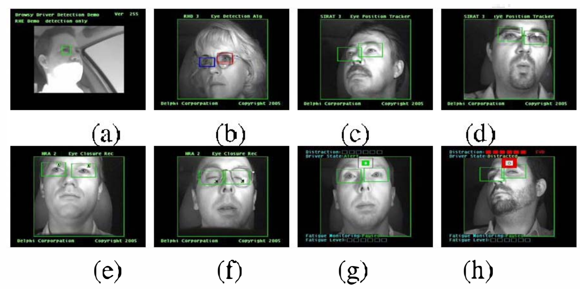

Fig. 1

SNAPSHOTS OF THE RESULTS: EYE DETECTION (IMAGES (A) AND (B)), DUAL EYE TRACKING (IMAGES (C) AND (D)), OPEN EYE (E), CLOSED EYE (F), FRONTAL HEAD POSE (G), AND NON-FRONTAL HEAD POSE (H).

REFERENCES

[1] Riad Hammoud, "Object Tracking And Eye State Identification Method", *USA and Europe Patent Pending, DP-310845, Filed on March 2004*
[2] Riad Hammoud and Andrew Wilhelm, "System and Method for Detecting an Eye", *US and Germany Patent Pending, DP-311385 (DEL01 P-539), Filed on May 2005*
[3] Riad Hammoud, Andrew Wilhelm, Harry Zhang and Gerald J. Witt, "System and Method to Determine Visual Awareness", *US and Germany Patent Pending, DP-311370, Filed on Nov 2004*
[4] Riad Hammoud and Phillip Malaway, "System and Method for Determining Eye Closure State", *US and Germany Patent Pending, DP-311369, Filed on Mar 10, 2005*
[5] Riad Hammoud, "A robust eye position tracker based on invariant local features, eye motion and infrared-eye responses", *Int'l Symposium on Defense and Security, Automatic Target Recognition XV, Proceedings of SPIE Vol. Nb. 5807, 2005*
[6] Riad I. Hammoud and Dan Witzner Hansen, "Biophysics of the eye in computer vision: Methods and Advanced Technologies", *in "Physics of Automatic Target Recognition", Edited by Firooz Sadjadi and Bahram Javidi, Springer-Verlag, 2005, To appear.*
[7] Riad I. Hammoud and Roger Mohr, "Mixture Densities for Video Objects Recognition", *International Conference on Pattern Recognition, Barcelona, Spain, pp. 71-75, 3-8 September, 2000.*
[8] Riad I. Hammoud, "Building and Browsing of Interactive Videos", *PhD Thesis, INRIA, INPG, Grenoble, France, Feb 27, 2001.*
[9] A. Douha, F. Cutzu, Riad I. Hammoud, and S. Kiselewich, "Triangulation based technique for efficient stereo computation in infrared images", *IEEE Intelligent Vehicles Conference (IEEE IV'03), Columbus, Ohio, USA, June 9-11, 2003.*
[10] Riad Hammoud and Zeeshan Rasheed, Editors of "Interactive Video: Algorithms and Technologies", *Springer-Verlag, 2005, To appear.*