Fast 2 Dimensional Velocity Estimation from Insect Inspired Motion Detection

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I. Abstract

The processing of visual motion information is one of the most fundamental and elementary functions performed by biological visual systems. Derived from neurobiology studies the Reichardt correlator model [1] has been extensively studied and used for motion detection. A digital template model proposed more recently by Horridge [2] simplifies the calculation but removes all dependency on velocity at the output of the detector. To compensate for this X.T. Nguyen [3] used tracking of the motion templates to estimate velocities. Based on Horridge template model we propose here an original resolution dependent velocity detector that does not required any tracking for velocity estimation.

Our model improves Horridge model by an algorithm which handles the processing of an entire video frame in 2 dimensional directions. We then implement a fast elementary velocity detector sensitive only to the velocity of one pixel per frame. Applied to lower resolutions format of the same input video this elementary velocity detector will detect higher velocities and thus a wider range detector based on that multiple resolution architecture is realized.

A frame subtraction followed by a threshold operation allows detecting the locations of changes in intensities. Then by using simple Boolean operations on shifted versions of the previous step output, the detection of the 8 templates for vertical direction motion and 8 others for horizontal direction motion is achieved. This is done for each pixel of each frame apart from the surrounding ones in order to associate motion in the four sensitive directions to each single photoreceptor as stated by the model designed in figure 1. [2]

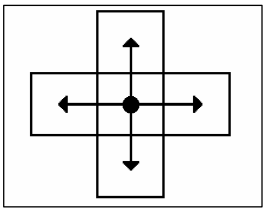

Fig. 1. Model of motion association to photoreceptors (pixels)

A pre filter is applied to the input video prior to the detector to make this one more robust to noise and more efficient in detecting moving edges. It uses a combination of the Sobel operator with a Gaussian smoothing in the fashion stated in equation 1. Thus noise is erased and edges are highlighted to the detector.

$$Out_A = \sqrt{((Gx * Gaussian_1) * I)^2 + ((Gy * Gaussian_1) * I)^2}$$

Eq 1. Preprocessing "Gaubel" filter

Using the principle of simple Boolean operations on shifted frames, a specific velocity (according to the size of the shift applied) can be detected by matching templates over space and time. Such a detector is therefore fast and efficient but is however only sensitive to a specific velocity and direction depending on the shift selected. Moreover the faster the movement is the fuzzier is the edge to be detected in the frame. To benefit from it, a single elementary velocity detector is used to lower resolution inputs to detect higher velocity. And by matching all those multiple resolution outputs a full velocity range can be detected.

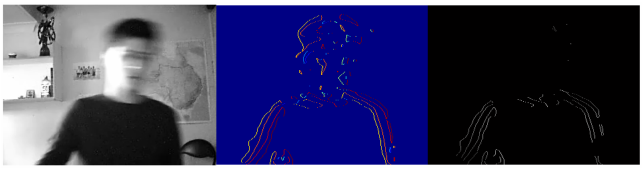

Fig. 2. Input frame (left), template detection (middle), velocity estimation (right)

References

[1] B. Hassenstein and W. Reichardt, *Functional structure of a mechanism of perception of optical movement*, in *Proc. Int. Cong. Cybern*, Namur, 1956, pp. 797-801 .

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