MORPHOLOGICAL DOMINANT POINTS DETECTION FOR MOTION ANALYSIS ON PROGRAMMABLE RETINA

J.Richefeu

École Nat. Sup. de Techniques Avancées
Unité d'Électronique et d'Informatique
32, Boulevard Victor
75015 Paris, France

ABSTRACT

This paper presents the first results of my PhD thesis, which addresses the problem dominant points detection for motion analysis on programmable retina. The goal of this research is to develop new algorithmical concepts to implement efficient image processing tools over the massively parallel cellular array of processors of the programmable retina, in order to perform effective motion analysis tasks.

Key words: dominant point, thinning algorithm, motion analysis, parallel cellular machine

1. INTRODUCTION

The detection and the analysis of the motion group together a several number of tools which motion field estimation is a great example. It allows us to compute the amplitude and the orientation of the motion with a sequence of images.

The dominant points detection is the first step involve in correlation to match different images on a sequence. We present a new algorithm to compute dominant points on a grey level image founded on mathematical morphology (section 2), then we explain why it is well adapted to SIMD cellular and how use it in a motion analysis framework (section 3).

2. MORPHOLOGICAL DOMINANT POINTS DETECTION

The dominant points is a location in the image where the signal changes in several directions, thus carrying more information. Examples includes corners and T-junctions, as well as locations where texture varies significantly. References for a quasi-exhaustive surveys are [2] and [7].

Mathematical morphology is a nonlinear image processing framework developed by G.Matheron and J.Serra [6]. Level sets represent a natural way to extend the morphological operator from binary to gray-level images.

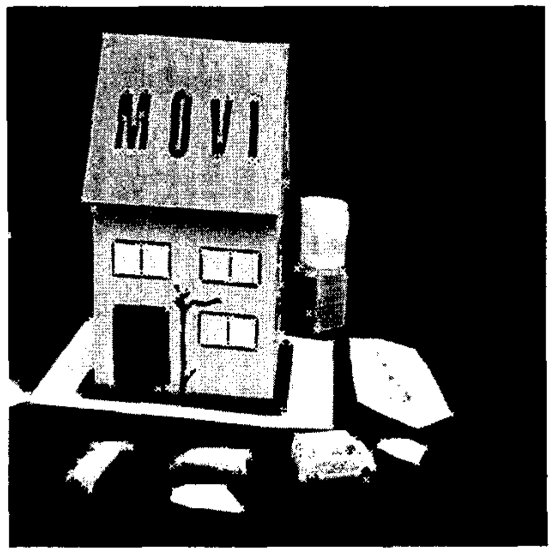

Figure 1: The resulting dominant points detection image on a "MOVI" database test image of the INRIA.

The principle of our algorithm is to compute one iteration of the MB1-Hybrid thinning algorithm [4] of each gray-level of the image (the skeleton) and of the complementary of the image (the exoskeleton). Then, we take the extremal points of the branches of the skeleton and the extremal points of the branches of the exoskeleton in order to obtain the interest function by summing this extremal points. The dominant points are then obtained by thresholding this function [5].

The dominant point detection algorithm that we have developed can be executed in parallel cellular machine like the programmable retina very efficiently. The MB1-Hybrid thinning algorithm used in the implementation is a good trade-off between rotation invariance, efficiency and robustness. The number of dominant points can be tuned according to the contrast thanks to the thresholding and according to the size of the level sets through the scale-space framework.

3. THE PROGRAMMABLE RETINA

The programmable retina [1] is a CMOS array sensor in which a Boolean elementary processor has been integrated inside every pixel, so it is a cellular SIMD machine with optical input. This architecture has been shown [3] to be well suited for non-linear (Boolean) and level-by-level processing, thanks to an analog-to-digital conversion by multiple thresholding, that allows data processing during the acquisition. These reasons have led us to consider the mathematical morphology framework for dominant points computation.

The overall number of elementary Boolean parallel operations performed by gray level is less than 150. So if the programmable retina is controlled at a 10 Mhz frequence, the computation time for all the whole dominant points detection is less than 4 ms for 256 gray-levels and less than 0.5 ms for 32 gray-levels.

We can classify motion detection techniques with hypothesis according to which the camera is fixed or mobile. The motion detection group image difference methods and likelihood maxima. On the other hand, motion analysis is complete with the computing of field of motion vector (optical flow).

This methods are founded on the equation of conservation of the apparent movement of image $I(x, y, t)$:

$$I_{x,y,t} = I(x, y, t) = I(x + \delta x, y + \delta y, t + \delta t) \qquad (1)$$

A multi-resolution approach allows us to considerate the superior order of the pixel. This equation only cannot be solved without adjonction of supplementary constraints to garant the uniqueness of the solution. This is the case of regulation constraint introduced Horn and Schunck widely used in actual differential methods.

So, after complete the dominant points detection on several images of a same sequence of images, we were able to compute the optical flow by matching results and then deduce some other properties like distance between objects, between us and an object, the speed of an object and the self motion of the image sensor.

As we work with a scale-space by choosing the level sets, we have certain possibilities to modulate the computation of optical flow in some regions of the image. This properties allow us not to compute redondant information due for example to the background of the image.

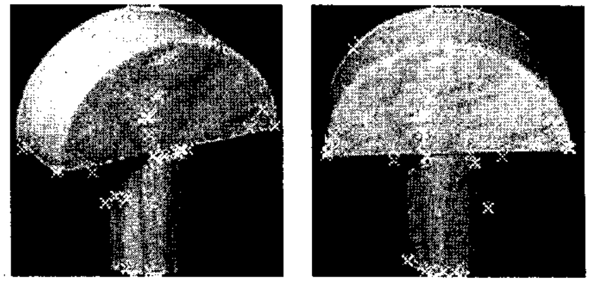

Figure 2: The result of dominant points detection on two images of the same sequence.

4. CONCLUSION

This study is part of our current research in the field of motion analysis. In following works, we will automatically detect and study motion on a video system based on artificial retina.

The optical flow informs us in several numbers of parameters useful for motion analysis. However, some conditions give the results different to real movement. This is the case for object without textures for which the optical flow is null. We have then to develop specifics methods to be able to treat the largest configurations.

5. REFERENCES

[1] T.M. Bernard, "Des rétines artificielles intelligentes", *phD Thesis*, Université Paris-Sud, 1992.

[2] R. Deriche and G. Giraudon, "A computional approach for corner and vertex detection", *IJCV*, vol. 10(2), pp. 101-124, 1993.

[3] A. Manzanera, "Vision artificielle rétinienne", *phD Thesis*, ENST, 2000.

[4] A. Manzanera and T.M. Bernard, "Metrical properties of a family of 2D parallel thinning algorithm", IWCIA, *Electronic Lecture Notes on Discrete Applied Mathematics*, Elsevier Science, Palermo, May 2003.

[5] J. Richefeu and A. Manzanera, "A morphological dominant points detection and its cellular implementation", *ISSPA'03*, Paris, Jully, 2003.

[6] J. Serra, *Image analysis and mathematical morphology*, New York, Academic Press, 1982.

[7] C. Schmid et al., "Comparing and evaluating interest points", *ICCV*, Bombay, January, 1998.