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Computer vision analysis of image motion by optical flow

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***Abstract*-One of the technically challenging is analyse the motion of object across frames to estimate its current velocity and predict its position. Here, we investigate the use of computer vision for automatic tracking and acquisition of knowledge about motion estimation. To get information about moving objects, we can track their motion by using optical flow methods. This article addresses the task of estimating the motion of object by the algorithm of Horn & Schunck. Preliminary results show that one can estimate the speed and the motion behavior.**

Keywords: motion analysis, Differential methods, Tracking, Motion behavior, Horn and Schunck.

I. INTRODUCTION

Motion estimation has increasing interest in computer vision and image processing, because there for a large number of applications used in this domain. For example: object tracking (video-surveillance, robotics), complex behavioral analysis (modelling of human body movements, meteorology), medical analysis (cardiac contraction follow-up, infarction detection) [1].

The motion estimation based on to study the displacement of each pixel of an image or region in motion to obtain vectors representing the speed, by making the assumption that the luminous intensity is preserved during the displacement. The apparent movement from the changes in the spatial distribution of intensity is called optical flow. The initial method of estimating the optical flow proposed by Horn and Schunck has led to multiple methods that can be classified into four main categories[2]: differential methods, frequency methods, block matching methods and methods based on parametric models of motion [3].

In this work, we chose the differential methods because of their robust and accurate with ease of implementation due to their differential nature. The optical flow equation also allows for sub-pixel motion estimation. motion measurement only requires a local calculation of the spatiotemporal derivatives of the sequence as shown in the study [4]. Finally, The aim of this work is to use differential methods to estimate the motion of an object, determine its direction and evaluate its speed. We organized this paper as follows: the first section is an introduction, the second section recalls the principles of motion estimation for the computation of the velocity vector field, third section presents the results, in section four we end with a conclusion and a perspective.

II. MOTION ESTIMATION

A. Basic principle

Motion estimation techniques consist in measuring the optical flux represented by the variations of the luminance between two images. The principle is based on the assumption of the conservation of the luminous intensity of a pixel along the trajectory of the movement [2].
In a sequence of digital images, it can be represented by its luminance function I (x, y, t) where the luminous intensity I is conserved between two successive images at times t and t + dt. It is written in the general form:

$$I(x+dx, y+dy, t+dt) \approx 0 \qquad (1)$$

Applying the Taylor formula to order 1 and dividing by dt, the equation (1) leads to:

$$\frac{dI}{dt} = \frac{\partial I}{\partial x}\frac{dx}{dt} + \frac{\partial I}{\partial y}\frac{dy}{dt} + \frac{dI}{dt} \qquad (2)$$

By the assumption that the light intensity does not vary with time, we have: $\frac{dI}{dt} = 0$.

If we note $I_x = \frac{\partial x}{\partial t}, I_y = \frac{\partial y}{\partial t}$ et $t = \frac{\partial I}{\partial t}$, the 3 components of the gradient according to (x, y, t) And $u = \frac{\partial x}{\partial t}, v = \frac{\partial y}{\partial t}$, the 2 speed components according to the directions (x, y), the optical flow equation can be summed up in the following wording:

$$I_x u + I_y v + I_t = 0 \qquad (3)$$

This equation is called the motion constraint equation. In order to find a unique solution for the two components of the velocity V = (u, v), we need two independent equations, which is not the case, because the only equation (3) does not make it possible to uniquely determine the optical flux. We are in the presence of an ill-posed problem which is often called the Aperture Problem, hence the need for the use of additional constraints to estimate the movement. Depending on the type of constraint used, different methods are obtained, the two main ones being Horn & Schunck and Lucas & Kanade.

B. Horn & Schunck algorithm:

Horn and Schunck develop a method to calculate the optical flow by combines the motion constraint equation with an overall regularization, due to a smoothing term on the sum of the squares of the modules of the velocity component gradients by minimizing the following equation [2]:

$$\iint_D (\nabla I . V + I_t)^2 + \alpha^2(\|\nabla u\|^2 + \|\nabla v\|^2)dxdy \quad (4)$$

Where the scalar α is a weighting coefficient that adjusts the influence of the smoothing (regularization) term. An iterative algorithm minimizes the integral defined on the D domain. Iterative equations are:

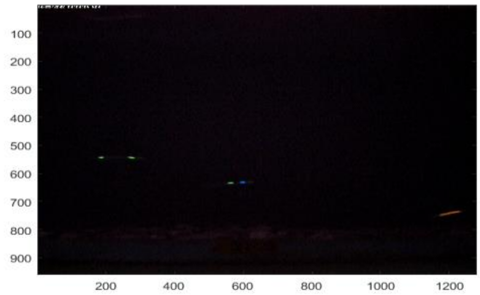
$$u^{k+1} = \overline{u}^k - \frac{I_x[I_x\overline{u}^k + I_y\overline{v}^k + I_t]}{\alpha^2 + I_x^2 + I_y^2}$$

$$v^{k+1} = \overline{v}^k - \frac{I_x[I_x\overline{u}^k + I_y\overline{v}^k + I_t]}{\alpha^2 + I_x^2 + I_y^2} \quad (5)$$

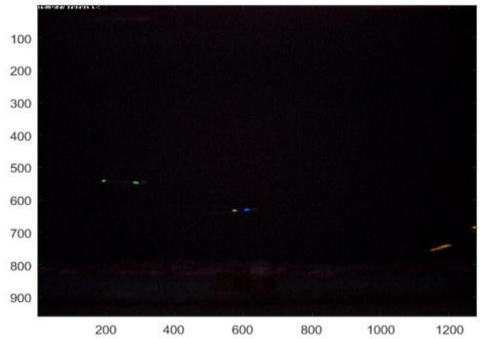
where Ix, Iy, It are the components of the gradient according to x, y, t and $\overline{u}, \overline{v}$ are the average values calculated using a weighted neighbour and k are the iteration index. The quality of the estimate strongly depends on the chosen derivation formulas.

III. RESULTS

To define the basics motion, we present the results of Horn and Schunck algorithm, which used two consecutive images to shows fish movement in more detail (Figure 1). The original image (a) contains: a fish marked with a double closed green (GGS) in the upper right, and a second fish with a double short blue green (GBS) in the middle; and the third with a long double orange (OOL), and the next instant is the image (b). The direction of the current goes from the right to the left of the image.



(a)



(b)

Fig. 1. Two successive images {a: at the instant (t), b: at the instant t + dt}.

In this algorithm, we have optimized the results by adjusting the smoothing parameter (α= 1) and the number of iterations (i = 11). In Fig.2. (a) a vector velocity field was obtained with low flow in low intensity background areas.

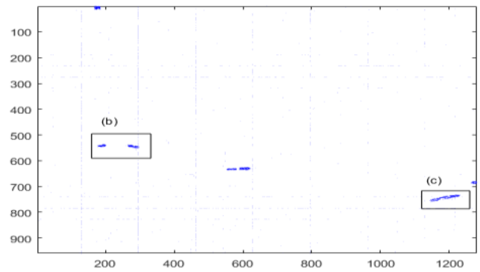
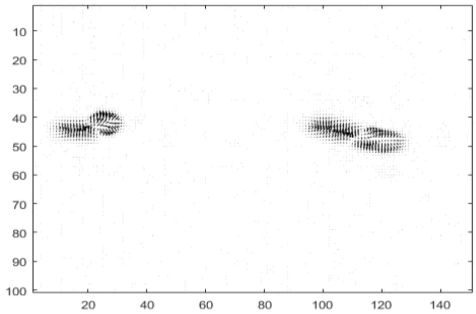
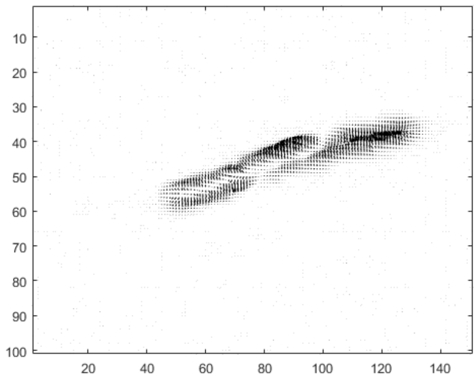


Fig.2. Global field of images (fig1: a, b)

To better visualize the optical flux, each vector field has been zoomed in Fig.3. for each, we have a velocity vector field with two different orientations of arrow: the one is orientated inside towards the origin which corresponds to the starting position of the fish (convergence) and the other is oriented from the origin towards the outside which corresponds to the position of its displacement (divergence). We can also identify the direction of movement that will be from convergence to divergence. For example, here, the fish in zone (b) moves to the right of the image and in zone (c) to the left of the image. We obtain in Fig.4, the velocity vector field superimposed on the chosen area.

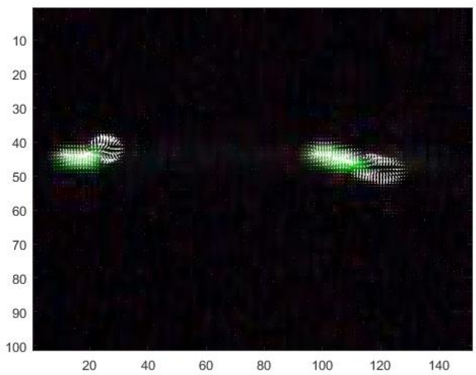


(b)

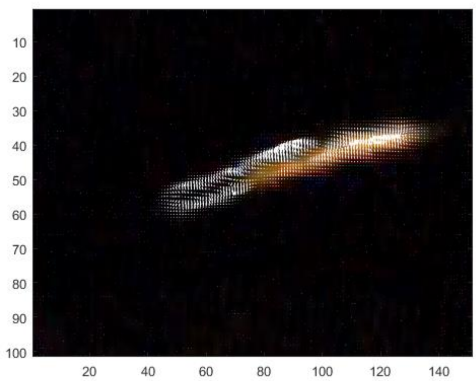


(c)

Fig. 3. Zoom on the area on image (fig.2: b, c).



(a)



(b)

Fig. 4. velocity vector field superimposed on the chosen area.

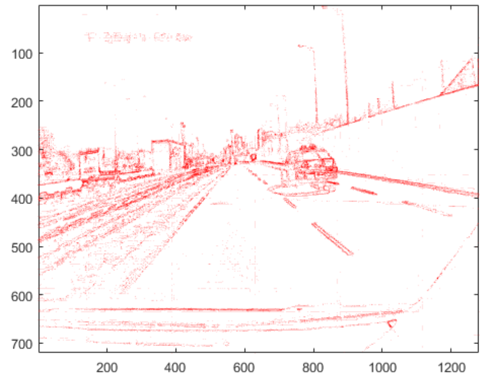
Converging field intensity indicates the tail and the divergent field intensity indicates the head, thus the direction of movement of the fish is inferred [9][10]. Moreover, the tail of a fish has a weaker field strength than the tail.

These algorithms were tested on a set of images for determining the flow field:

a) First image of the sequence x.

b) Second image of the sequence x.

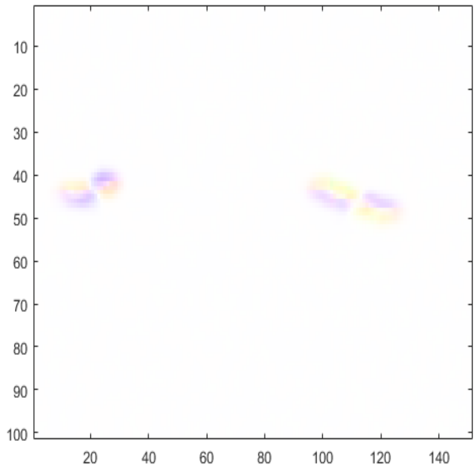
c) Field superimposed on the image (a)



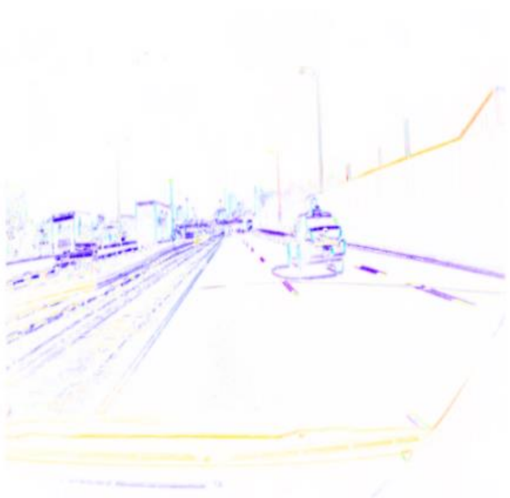
d) Vector velocity field of images (a, b)

Fig. 5. Car on the highway road

The use of a colour map makes it possible to represent the flow direction as well as its intensity so dense. The velocity vectors are represented by the colors contained in the disk of the figure 6.d. Each velocity vector is encoded by the color depending on its angle and its intensity.

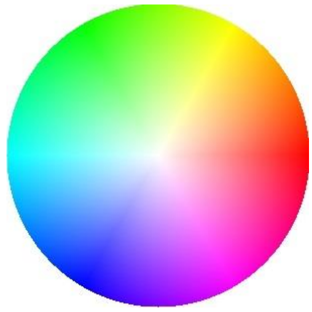


a) Flow of fish.



b) Flow of car.

c) Flow of a person.



d) Colour disk.

Fig. 6. represent the flow direction with color map

IV. Conclusion and Perspective

The differential method of Horn & Schunck is repeated in this article. The computation time of the optical flux of a pair of images obtained with Matlab is typically: 0.14s for this method. Horn & Schunk's global method specifies the undulatory motion fish that could be used as a proxy for the energy expenditure related to swimming. for example, the biologists couple these measures of speed and range of motion with their weight loss and their metabolism.

Finally, the ultimate goal of this project is the automation of these measures in order to reduce the working time of the observer. For it, we have in perspective, due to the fusion of the results obtained by the main phases of treatment (motion detection, contour detection and color segmentation), to build a tool allowing the automatic tracking of object integrating their sense, speed and ripple energy.

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