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VISÃO POR COMPUTADOR TP5
Estimação de Movimento
(Cálculo do Fluxo Óptico)

Motion estimation
(Calculation of Optical Flow)
The most direct process of estimating velocity in a body image is to differentiate its
Location in the image over time, that is, to obtain its speed based on temporal information
Position. However this process forces you to know its location in the image. In case of
This may imply additional difficulties. This process is also dependent on the
Of noise in the images.
A solution for estimating the velocity in the image of an object is to explicitly calculate the Projected motion components in the image (optical flow). The optical flow is defined as the Apparent displacement of the brightness patterns in the image being obtained for each point of the image (X, y) is a velocity vector representing the velocity estimated for that point. Your calculation can be accomplished in several ways. In particular the calculation can be made on the basis of gradient.

Estimation of flow based on gradient

I (x, y, t) represents the brightness in the pixel (x, y) at time t. For each pixel it is estimated a vector of
Velocity, creating a field of velocity vectors called optical flow. Let (vx, vy) be the
Components of the velocity vector in the pixel (x, y). After a time interval Δt the point (x, y) moves
In the image to the coordinate point $(x + vx. \Delta t, y + vy. \Delta t)$. Considering that the brightness of the pixel does not
Has changed (preserving the brightness of the image) then:

$$I(x, y, t) = I(x + v_x.\Delta t, y + v_y.\Delta t)$$

Or, what is equivalent (given the constancy of the brightness),

$$\frac{dI}{dt} = 0$$

The function I (x, y, t) depends on the spatial coordinates of the image, x and y and also on time t. On the other hand x and y are in turn also function of time t. Thus the total derivative in Equation (1) should not be confused with the partial derivative dCircle I / dCircle t.
Applying the rule of the differentiation of compound functions is obtained for the total temporal derivative,

$$\frac{dI(x(t), y(t), t)}{dt} = \frac{\partial I}{\partial x}\frac{dx}{dt} + \frac{\partial I}{\partial y}\frac{dy}{dt} + \frac{\partial I}{\partial t} = 0$$

The partial derivatives of brightness in relation to x and y are simply the components of the spatial gradient of
Image I I and the derivatives in order of time dx / dt and dy / dt are the components of the optical flow (vx, vy). Or image ∇ Be

Or yet $\nabla I.(v_x, v_y) + I_t = 0$

Equation (3) is an equation with two unknowns vx and vy. Consequently, the velocity vector can not
Be calculated without additional restrictions. So one way to solve the problem is to minimize the function:

$$E = \sum_{x,y} (I_x v_x + I_y v_y + I_t)^2 \qquad (4)$$

For this it is necessary to specify a shape for the components of the velocity vector (vx,vy). If Consider that vx and vy are constants or that is,

Vx = ax
Vy = ay

The components of the velocity vector can be obtained as a solution of the system of equations,

$$\begin{aligned} \left(\sum_i I_{x_i}^2\right).a_x + \left(\sum_i I_{x_i} . I_{y_i}\right).a_y &= -\sum_i I_{x_i} . I_{t_i} \\ \left(\sum_i I_{x_i} . I_{y_i}\right).a_x + \left(\sum_i I_{y_i}^2\right).a_y &= -\sum_i I_{y_i} . I_{t_i} \end{aligned} \qquad (5)$$

That is obtained by deriving Equation (4) in order to the components of the velocity vector ax and ay and equating the zero.
If, on the other hand, we specify that vx and vy have the form (related model):

$$\begin{aligned} v_x &= a_x + b_x . x + c_x . y \\ v_y &= a_y + b_y . x + c_y . y \end{aligned} \qquad (6)$$

So if we replace the expressions of vx and vy (Equation (6)) in Equation (3), and derive Equation (3) in order to the components ax, bx, cx, ay, by, cy of the velocity vector and equaling zero , One obtains:

$$\begin{bmatrix} \sum I_x^2 & \sum xI_x^2 & \sum yI_x^2 & \sum I_xI_y & \sum xI_xI_y & \sum yI_xI_y \\ \sum xI_x^2 & \sum x^2I_x^2 & \sum xyI_xI_y & \sum xI_xI_y & \sum x^2I_xI_y & \sum xyI_xI_y \\ \sum yI_x^2 & \sum xyI_x^2 & \sum y^2I_x^2 & \sum yI_xI_y & \sum xyI_xI_y & \sum y^2I_xI_y \\ \sum I_xI_y & \sum xI_xI_y & \sum yI_xI_y & \sum I_y^2 & \sum xI_y^2 & \sum yI_y^2 \\ \sum xI_xI_y & \sum x^2I_xI_y & \sum xyI_xI_y & \sum xI_y^2 & \sum x^2I_y^2 & \sum xyI_y^2 \\ \sum yI_xI_y & \sum xyI_xI_y & \sum y^2I_xI_y & \sum yI_y^2 & \sum xyI_y^2 & \sum y^2I_y^2 \end{bmatrix} \begin{bmatrix} a_x \\ b_x \\ c_x \\ a_y \\ b_y \\ c_y \end{bmatrix} = \begin{bmatrix} \sum I_xI_t \\ \sum xI_xI_t \\ \sum yI_xI_t \\ \sum I_yI_t \\ \sum xI_yI_t \\ \sum yI_xI_t \end{bmatrix}$$

Obtaining the partial derivatives

The partial derivatives Ix, Iy and It are obtained by means of numerical differentiation, for example, in a 2x2x2 cube. The elements of this cube give the pixel values in one region of an image, in two consecutive images. If the gray level in the pixel (x, y) is represented at the instant of time t by I (i, j, t), the partial derivatives are approximated by

$$I_x \approx \frac{1}{4}\left(I(i+1,j,t)+I(i+1,j,t+1)+I(i+1,j+1,t)+I(i+1,j+1,t+1)\right)-$$
$$-\frac{1}{4}(I(i,j,t)+I(i,j,t+1)+I(i,j+1,t)+I(i,j+1,t+1))$$

$$I_y \approx \frac{1}{4}\left(I(i,j+1,t)+I(i,j+1,t+1)+I(i+1,j+1,t)+I(i+1,j+1,t+1)\right)-$$
$$-\frac{1}{4}(I(i,j,t)+I(i,j,t+1)+I(i+1,j,t)+I(i+1,j,t+1))$$

$$I_t \approx \frac{1}{4}(I(i,j,t+1)+I(i,j+1,t+1)+I(i+1,j,t+1)+I(i+1,j+1,t+1))-$$
$$-\frac{1}{4}(I(i,j,t)+I(i,j+1,t)+I(i+1,j,t)+I(i+1,j+1,t))$$

By calculating the partial derivatives by means of these expressions, the components of the velocity vector are calculated in the center of the cube 2x2x2, that is between every 4 pixels of an image and between two images consecutives

JOB:
The purpose of this paper is to calculate the motion components of a
*Images (optical flow). Reduce the size of the images to a maximum of 50 * 50.*
Work to be done:
1. Use the "coins.png" image.
2. Simulate the existence of movement, creating a second and a third image in which
Image " coins " in the following directions (create an image for each movement):
1 horizontal pixel (between the 1st image and the 2nd image and between the 2nd image and the 3rd image).
1 vertical pixel (between the 1st image and the 2nd image and between the 2nd image and the 3rd image).
1 pixel diagonal (between the 1st image and the 2nd image and between the 2nd image and the 3rd).
3. Calculate the optical flow in the image considering the constant model for the motion (calculate the flow
*In all pixels using 3 * 3 regions / windows around each pixel). To do this, first calculate Ix, Iy, It. Calculate the flow between the 1st image and the 2nd image and between the 1st image and the 3rd image.*
4. Repeat point 3, but considering the related model for the motion (calculate the flow at all
*Pixels using 3 * 3 regions / windows around each pixel). To do this, start by calculating*
Ix, Iy, It

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*5. For points 3 and 4, calculate the mean motion vectors (in regions 3 * 3) and compare them with the*
Original movement imposed. Also determine your standard deviation (in module and direction).
6. Display the motion vectors in the image.
NOTE: Present the vectors at sufficiently spaced points to allow
The flow of movement (Ex: 20 pixels)
7. Create a 2nd image but now with different directions and modules
Image divided into 4 or more regions, each of which has a different movement). Calculate or Flow using the constant model and the like and present in the image the calculated motion vectors. Comment

1.2.3
See code in tp5.m and partialDerivatives.m