Determining Optical Flow

光流测定

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什么是光流

从本质上说，光流就是你在这个运动着的世界里感觉到的明显的视觉运动

光流的概念是Gibson在1950年首先提出来的。它是空间运动物体在观察成像平面上的像素运动的瞬时速度，是利用图像序列中像素在时间域上的变化以及相邻帧之间的相关性来找到上一帧跟当前帧之间存在的对应关系，从而计算出相邻帧之间物体的运动信息的一种方法。一般而言，光流是由于场景中前景目标本身的移动、相机的运动，或者两者的共同运动所产生的。

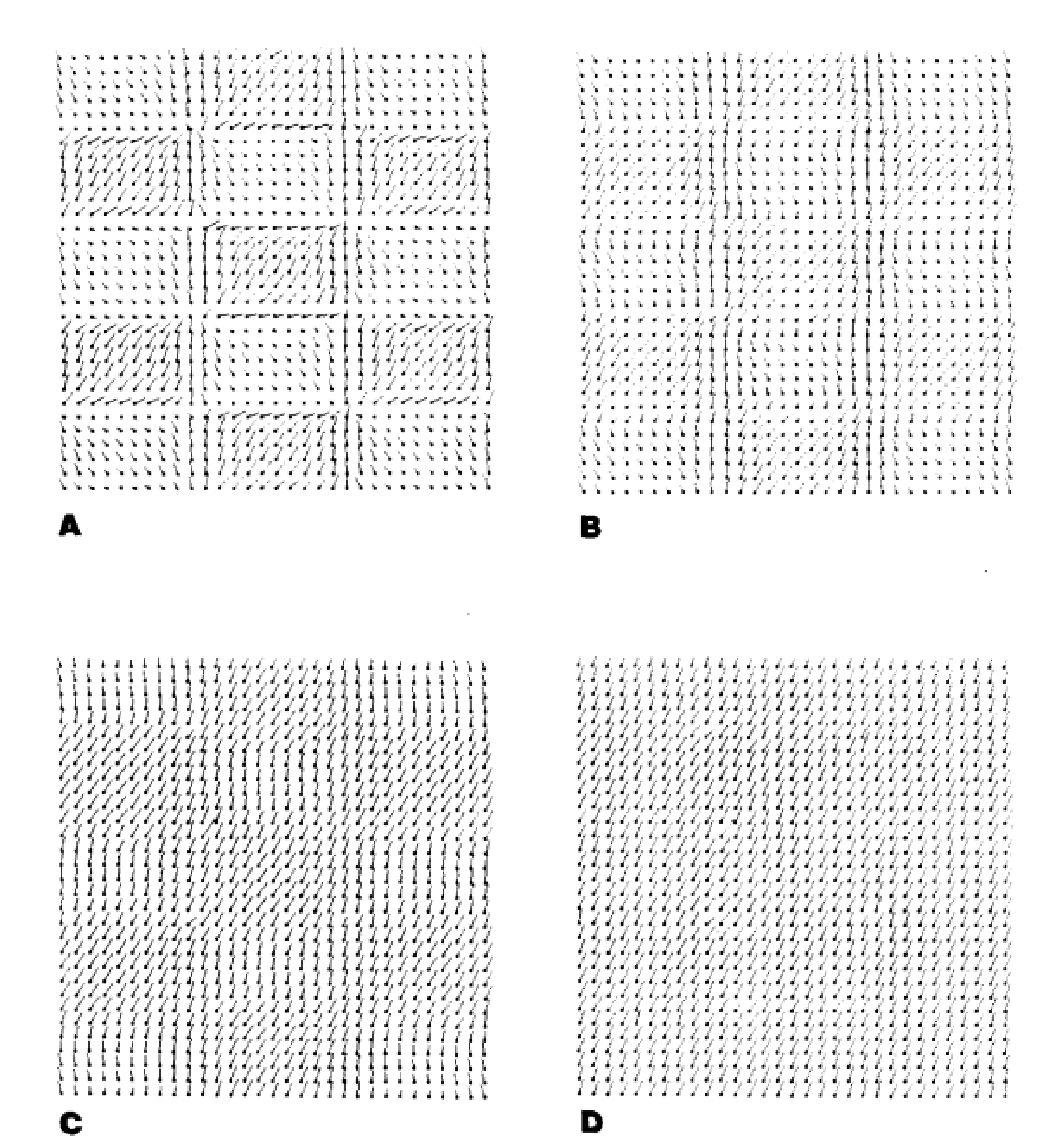

0
50
100
150
200
250
300
350
0
100
200
300
400
500
600

论文讲解

abstract+results

ABSTRACT

Optical flow cannot be computed locally, since only one independent measurement is available from the image sequence at a point, while the flow velocity has two components. A second constraint is needed. A method for finding the optical flow pattern is presented which assumes that the apparent velocity of the brightness pattern varies smoothly almost everywhere in the image. An iterative implementation is shown which successfully computes the optical flow for a number of synthetic image sequences. The algorithm is robust in that it can handle image sequences that are quantized rather coarsely in space and time. It is also insensitive to quantization of brightness levels and additive noise. Examples are included where the assumption of smoothness is violated at singular points or along lines in the image.


A
B
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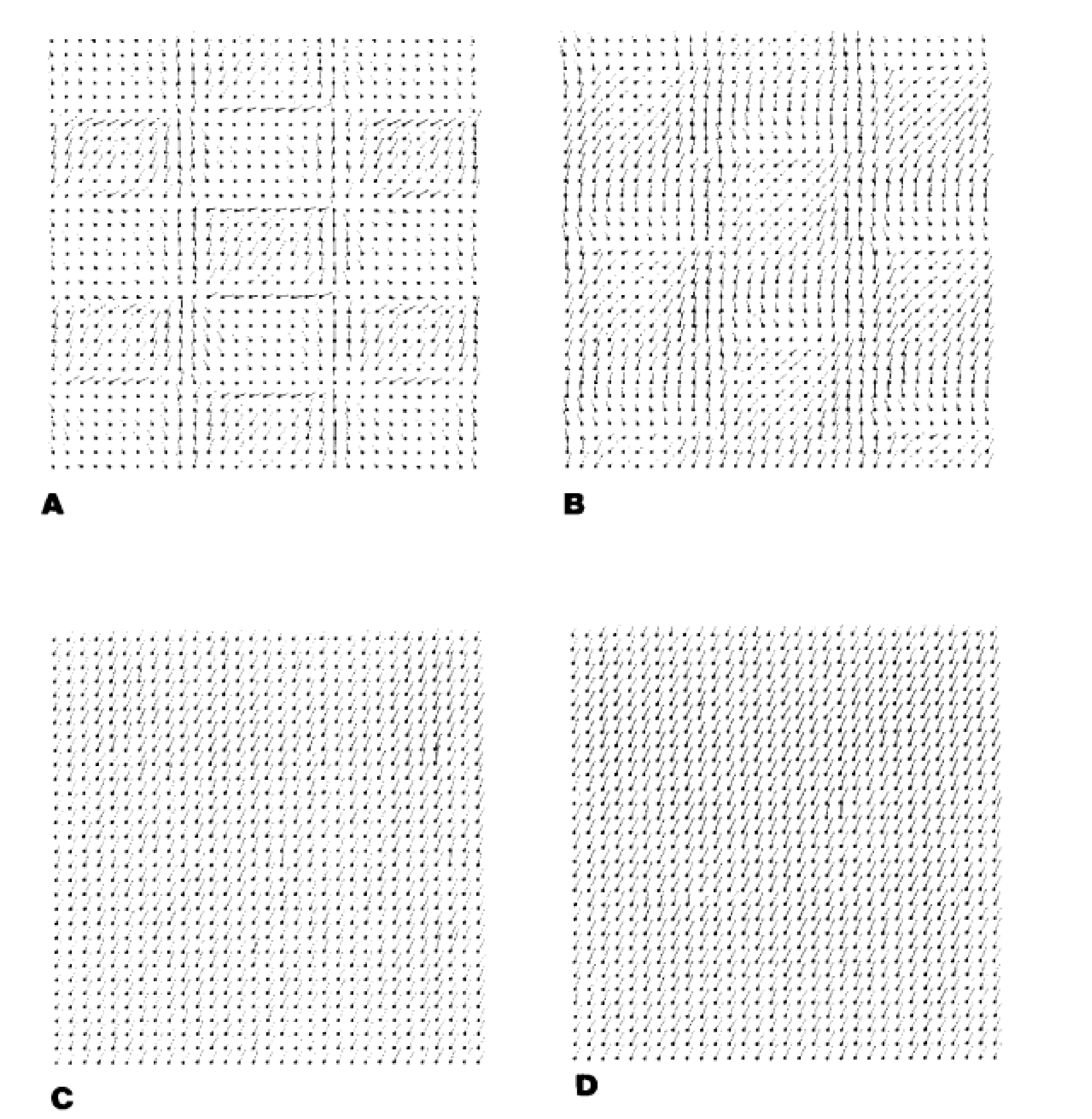
A
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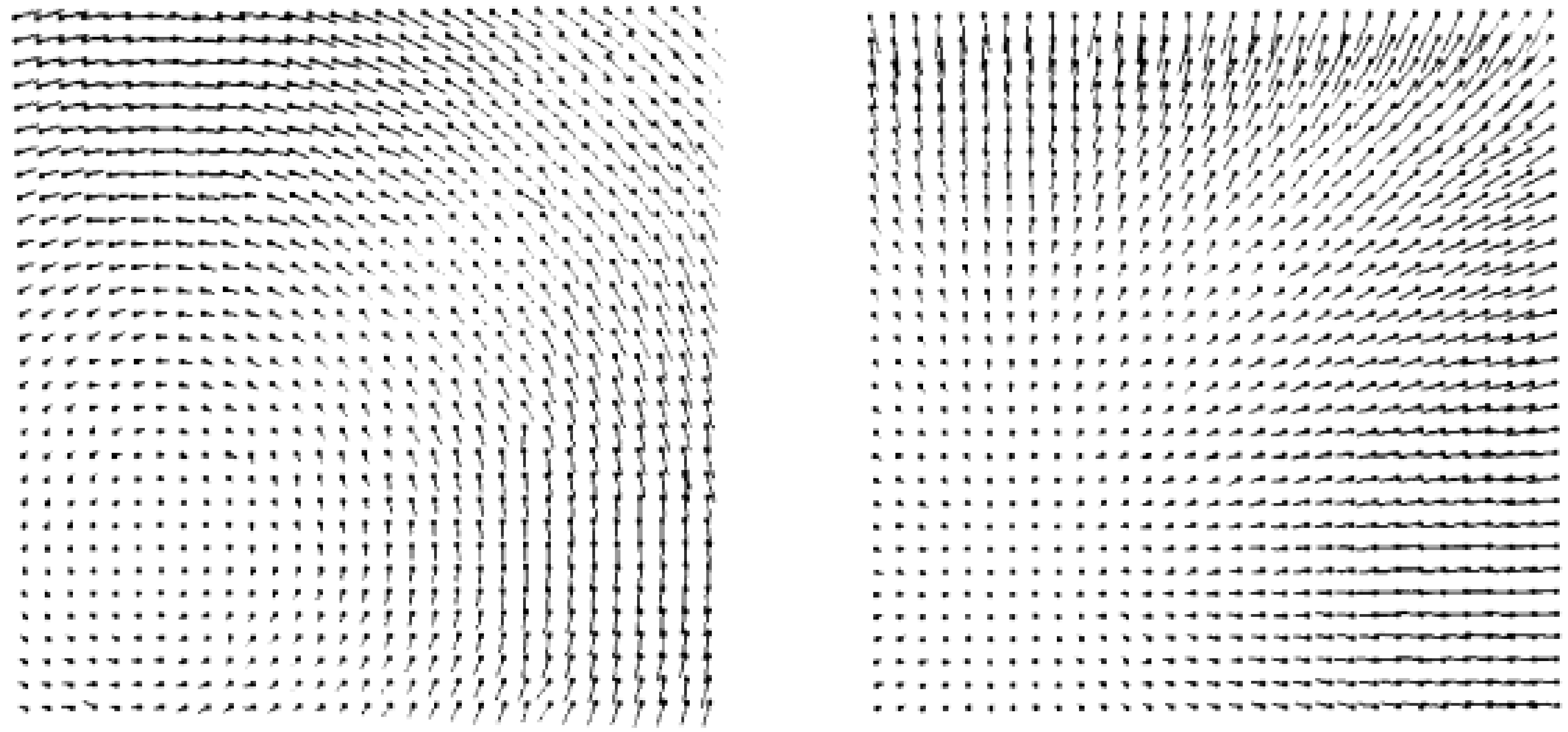
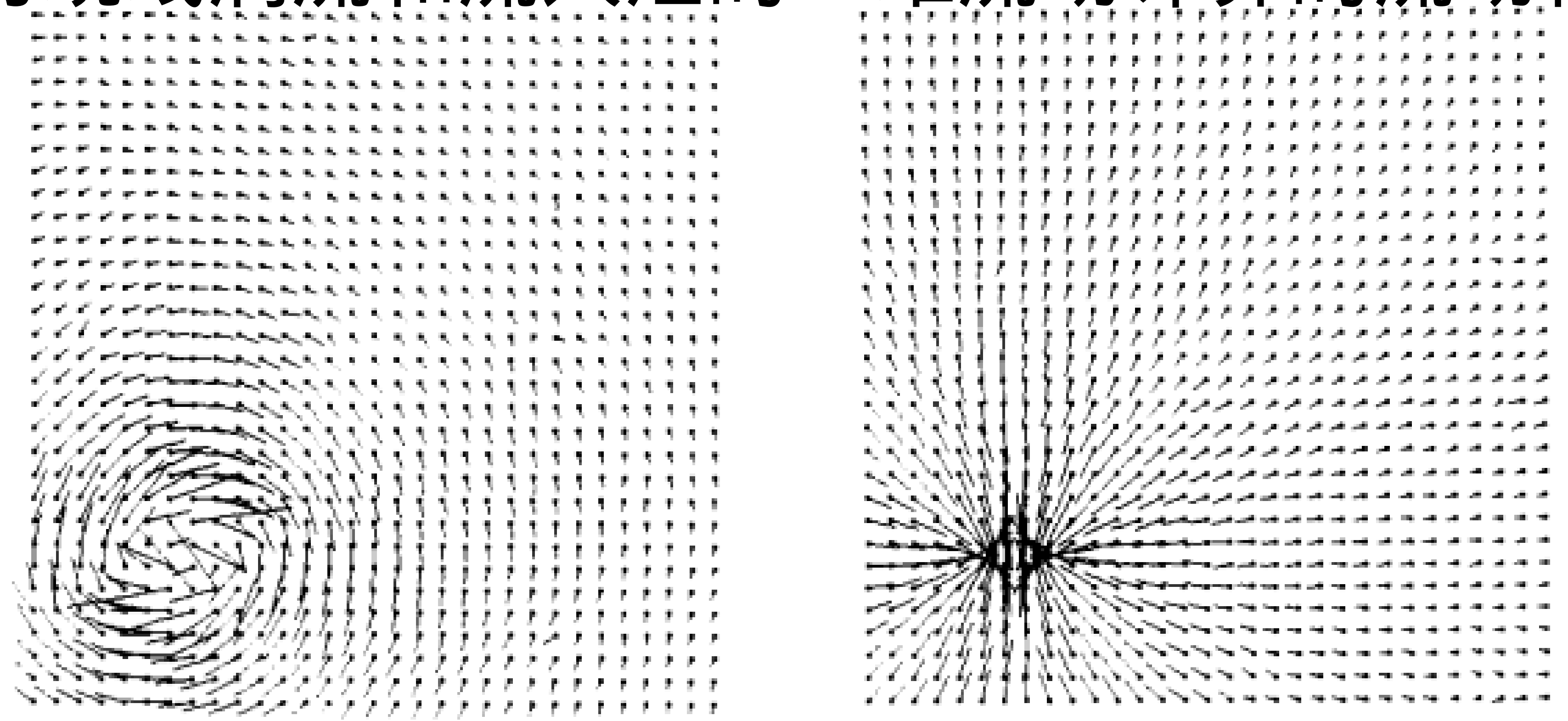


A **B**

FIG. 8. Flow patterns computed for simple rotation and simple contraction of a brightness pattern. In the first case, the pattern is rotated about 2.8 degrees per time step, while it is contracted about 5% per time step in the second case. The estimates after 32 times steps are shown.

9. 为绕线涡流和流入汇的二维流动计算的流动模式。



A **B**

FIG. 9. Flow patterns computed for flow around a line vortex and two dimensional flow into a sink. In each case the estimates after 32 iterations are shown.

两个条件

亮度恒定不变。即同一目标在不同帧间运动时，其亮度不会发生改变。这是基本光流法的假定（所有光流法变种都必须满足），用于得到光流法基本方程；时间连续或运动是“小运动”。即时间的变化不会引起目标位置（光的亮度）的剧烈变化，相邻帧之间位移要比较小。

Horn–Schunck光流算法

$$I(x,y,t) = \mathrm{I}(\mathrm{x}+\mathrm{dx},\mathrm{y}+\mathrm{dy},\mathrm{t}+\mathrm{dt}) \quad (1)$$

$$I(x,y,t) = \mathrm{I}(\mathrm{x},\mathrm{y},\mathrm{t}) + \frac{\partial I}{\partial x}dx + \frac{\partial I}{\partial y}dy + \frac{\partial I}{\partial t}dt + \varepsilon \quad (2)$$

$$\frac{\partial I}{\partial x}\frac{dx}{dt} + \frac{\partial I}{\partial y}\frac{dy}{dt} + \frac{\partial I}{\partial t}\frac{dt}{dt} = 0 \quad (3)$$

$$I_x = \frac{\partial I}{\partial x}, I_y = \frac{\partial I}{\partial y}, I_t = \frac{\partial I}{\partial t}$$

$$\mathrm{u} = \frac{dx}{dt}, v = \frac{dy}{dt} \quad (4)$$

u是光流延x轴的速度矢量
v是光流延y轴的速度矢量

$$I_x u + I_y v + I_t = 0 \quad (5)$$

$$\nabla^2 u = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \quad \text{and} \quad \nabla^2 v = \frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}.$$

$$\nabla^2 u \approx \ 3(\bar{u}_{i,j,k} - u_{i,j,k}) \quad 和 \quad \nabla^2 v \approx \ 3(\bar{v}_{i,j,k} - v_{i,j,k})$$

$$\begin{aligned}\bar{u}_{i,j,k} =& \frac{1}{6}\{u_{i-1,j,k} + u_{i,j+1,k} + u_{i+1,j,k} + u_{i,j-1,k}\} \\ &+ \frac{1}{12}\{u_{i-1,j-1,k} + u_{i-1,j+1,k} + u_{i+1,j+1,k} + u_{i+1,j-1,k}\}, \\ \bar{v}_{i,j,k} =& \frac{1}{6}\{v_{i-1,j,k} + v_{i,j+1,k} + v_{i+1,j,k} + v_{i,j-1,k}\} \\ &+ \frac{1}{12}\{v_{i-1,j-1,k} + v_{i-1,j+1,k} + v_{i+1,j+1,k} + v_{i+1,j-1,k}\},\end{aligned}$$

1/12	1/6	1/12
1/6	-1 i,j,k	1/6
1/12	1/6	1/12

$$E(u,v) = \iint [(I_x u + I_y v + I_t)^2 + \alpha^2 (\|\nabla u\|^2 + \|\nabla v\|^2)] dx dy$$

$$\frac{\partial L}{\partial u}-\frac{\partial}{\partial x}\frac{\partial L}{\partial u_x}-\frac{\partial}{\partial y}\frac{\partial L}{\partial u_y}=0$$
$$\frac{\partial L}{\partial v}-\frac{\partial}{\partial x}\frac{\partial L}{\partial v_x}-\frac{\partial}{\partial y}\frac{\partial L}{\partial v_y}=0$$

欧拉—拉格朗日方程组

$$I_x(I_x u+I_y v+I_t)-\alpha^2\Delta u=0$$
$$I_y(I_x u+I_y v+I_t)-\alpha^2\Delta v=0$$

用 $\Delta u(x,y)=\bar{u}(x,y)-u(x,y)$替换后，方程组变化为

$$(I_x^2+\alpha^2)u+I_xI_yv=\alpha^2\bar{u}-I_xI_t$$
$$I_xI_yu+(I_y^2+\alpha^2)v=\alpha^2\bar{v}-I_yI_t$$

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

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

谢谢大家