CMSC 426

Problem set 2

Due: Tuesday, November 11, 2003
Programming

(1) A geometric transform is a vector function **T** that maps the pixel (x, y) to a new position (x', y'). **T** is defined by its two components

$$x' = T_x(x, y) \qquad y' = T_y(x, y)$$

Geometric transformations are implemented in two steps. First for a point (x', y') we find from the inverse transform T^{-1} the corresponding point (x, y). Second, since x and y are not integers, we need to estimate the brightness value at (x, y) by interpolation (from neighboring integer points).

Develop programs for the following geometric transforms:

(a) Rotation

(b) Change of scale

(c) Skewing. Skewing by an angle ϕ is defined as

$$x' = x + ytan(\phi) \quad y' = y$$

(d) Affine transform calculated from three pairs of corresponding points. An affine transform is defined as

$$x' = a_0 + a_1 x + a_2 y \quad y' = b_0 + b_1 x + b_2 y$$

For each of the above transforms, implement the following two brightness interpolation approaches:

- Nearest-neighbor interpolation
- Bi-linear interpolation (from four neighboring points), which can be implemented as convolution, as discussed in class (slides on Resampling).

Run your algorithms on a picture of your choice. Print the code. Print your results for (a) Scaling by a factor 3 (b) An affine transform with points $A = (1, 0), B = (-1, 0), C = (0, \sqrt{3})$ mapping to points $A' = (1.9, 0), B' = (-0.5, 0), C' = (0, 1)$ using bi-linear interpolation.

(2) Implement the Lukas-Kanade optical flow algorithm using the implementation described in Barron et al. 1994. First compute the normal flow using the following steps:

(a) The image sequence is filtered with a spatio-temporal Gaussian filter, with standard deviation $\sigma = 1.5$ and kernel size $11 \times 11 \times 11$.

(b) The spatial and temporal derivatives are computed using the 5-point symmetric kernel $\frac{1}{12}(-1, 8, 0, -8, 1)$.

(c) Estimation of the normal flow at points with high spatial gradient (experiment with the threshold)

Estimate the optical flow from the normal flow values with weighted least squares minimization using the 5×5 separable and isotropic window function W^2. Its effective 1-d weights are $(0.0625, 0.25, 0.375, 0.25, 0.0625)$.

Print your code. Plot one estimated normal flow and optical flow field for the office sequence. There are twenty frames, so you can compute the flow for 6 frames in the middle of the sequence.

Problems

1. What is histogram equalization? Explain the rationale behind this technique.
2. Explain why Gaussian Filtering is often the preferred averaging method.
3. Explain why smoothing typically blurs image edges.
4. Aliasing takes high spatial frequencies to low spatial frequencies. Explain why the following effects occur:
   - In old cowboy films that show wagons moving, the wheel often seems to be stationary or moving in the opposite direction.
   - White shirts and thin dark pin-stripes often generate a shimmering array of colors on television.

- In ray-traced pictures, soft shadows generated by area sources look blocky.

5. Exercise 3.3 from Trucco and Verri
6. Explain why subtraction of a second derivative of the image function from the original image results in the visual effect of image sharpening?
7. What are LoG (Laplacian of Gaussian) and DoG (difference of Gaussian)? How do you compute them? How are they used?
8. Exercise 5.3 from Trucco and Verri (write the algorithm in pseudo code)