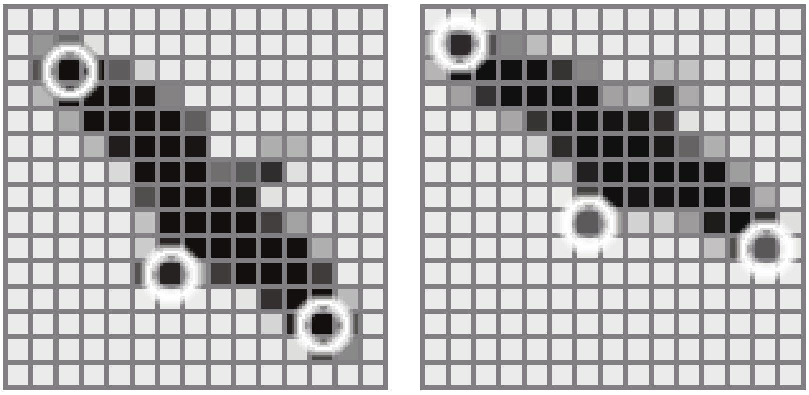
1 Pre-Recorded Tasks

1.1 Affine Motion Model

The images given below are two consecutive frames of a video sequence and we can assume that the sampling distance stays the same.



t t+1

The marked points (m_i, n_i) and (m'_i, n'_i) for $i = 1, 2, 3$ shall be used as corresponding points for the affine motion model

$$\begin{bmatrix} m' \\ n' \end{bmatrix} = \begin{bmatrix} a_1 & a_2 \\ a_3 & a_4 \end{bmatrix} \begin{bmatrix} m \\ n \end{bmatrix} + \begin{bmatrix} t_1 \\ t_2 \end{bmatrix}.$$

The parameters can be calculated if the shifts (k_i, l_i) with $i = 1, 2, 3$ are known:

$$\begin{bmatrix} k_1 \\ k_2 \\ k_3 \end{bmatrix} = \begin{bmatrix} m_1 & n_1 & 1 \\ m_2 & n_2 & 1 \\ m_3 & n_3 & 1 \end{bmatrix} \begin{bmatrix} a_1 - 1 \\ a_2 \\ t_1 \end{bmatrix}$$

$$\begin{bmatrix} l_1 \\ l_2 \\ l_3 \end{bmatrix} = \begin{bmatrix} m_1 & n_1 & 1 \\ m_2 & n_2 & 1 \\ m_3 & n_3 & 1 \end{bmatrix} \begin{bmatrix} a_3 \\ a_4 - 1 \\ t_2 \end{bmatrix}$$

1. Write down the systems of equations for the shift coordinates k_i and l_i!

2. Solving both systems of equations leads to the parameters for the affine motion model which can then be written as:

$$\begin{bmatrix} m' \\ n' \end{bmatrix} = \begin{bmatrix} 0.95 & -0.15 \\ 0.05 & 1.15 \end{bmatrix} \begin{bmatrix} m \\ n \end{bmatrix} + \begin{bmatrix} -0.4 \\ -1.6 \end{bmatrix}$$

   Interpret the result with regard to scaling, shearing, and translation!

2 Self-Study Matlab Tasks

2.1 Motion Estimation using Block matching

In this exercise we will implement a block matching algorithm for the estimation of motion within a sequence. Therefore, two frames of a sequence are provided. In the following we want to estimate the motion between them.
You can find a description of the block matching approach on page 8-12 of the script. Central element of this approach is the error metric that shows the similarity between two compared blocks.

1. As in the script we want to use the sum of squared differences (SSD) as metric here. Therefore, write a function `calc_ssd` that calculates the SSD between two equally sized blocks! Your function should accept two input parameters, an original image and a reference image to which it is compared.

2. For the next steps copy the provided file `Block_matching_provided.m` to your working directory. We want to use full search as search strategy here. Determine the limits of the two inner for-loops for k and l accordingly.

3. Calculate the SSD between all considered block pairs using your function from 2.1.1

4. Determine the motion vector for each block at the indicated position.

5. Show the first frame of the sequence and overlay it with a plot of the resulting motion vectors.

1 Pre-Recorded Tasks

1.1 Affine Motion Model

1. Write down the systems of equations for the shift coordinates k_i and l_i!

   For the frame at time t, the following object points can be extracted: (3,3), (11,7), and (13,13). For the frame at time $t+1$, the points are (2,2), (9,7), and (10,14). With these values, the corresponding shifts can be calculated. The shifts are (-1,-1), (-2,0), and (-3,1). Finally, the system of equations for the first shift coordinate is given below:

$$\begin{bmatrix} -1 \\ -2 \\ -3 \end{bmatrix} = \begin{bmatrix} 3 & 3 & 1 \\ 11 & 7 & 1 \\ 13 & 13 & 1 \end{bmatrix} \begin{bmatrix} a_1 - 1 \\ a_2 \\ t_1 \end{bmatrix}$$

$$\begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 3 & 3 & 1 \\ 11 & 7 & 1 \\ 13 & 13 & 1 \end{bmatrix} \begin{bmatrix} a_3 \\ a_4 - 1 \\ t_2 \end{bmatrix}$$

2. Interpret the result with regard to scaling, shearing, and translation!

   The object was shrinked in vertical direction and enlarged in horizontal direction. There was also a slight shearing and the object moved towards the upper left edge.

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