Motion Estimation
— BMA

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Outline

- Optical Flow (Pixel-level)
  - What is optical flow?
  - Lucas-Kanade algorithm (LK) [2]
  - Horn-Schunck algorithm (HS) [3]

- BMA (Block-level)
  - The principle of BMA
  - Full search scheme
  - Three step search [4]
  - New three step search [5]
  - Four step search [6]
 - Diamond search scheme [7]

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  - Diamond search scheme [7]

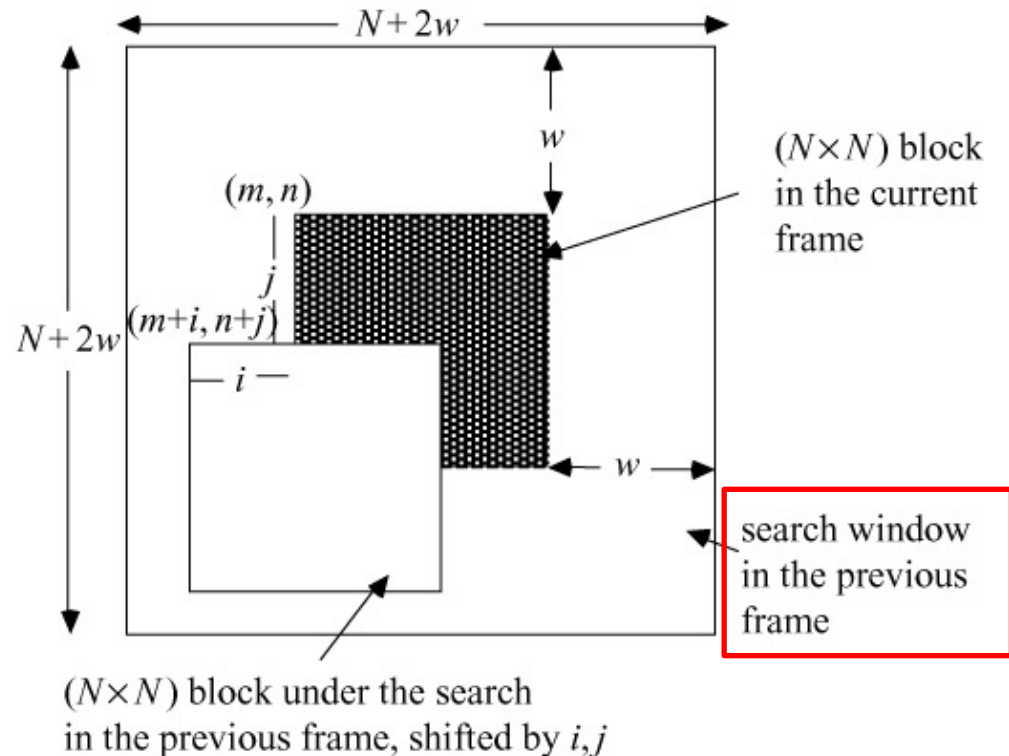# Correlation in Video Frames

To remove the **temporal redundancy** between successive frames.
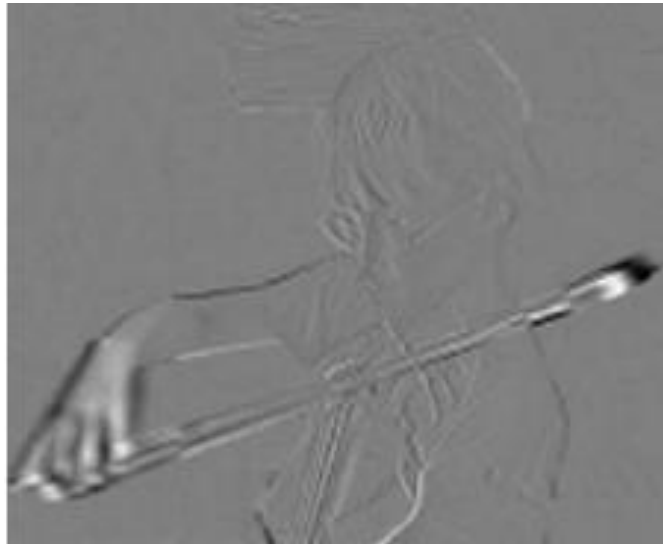
The Principle of BMA

- For each image-block, find the best matching block in the previously **encoded** frame.
  - Motion vector
  - The DCT transform coefficients of the **residual** signal will be transmitted.

$(N \times N)$ block under the search in the previous frame, shifted by i,j

Block-matching: Error Measure

- Mean Square Error (MSE)

$$MSE = \frac{1}{I*J}\sum_{i=1}^{I}\sum_{j=1}^{J}[f(i,j)-g(i-dx,j-dy)]^2$$

- Mean of the Absolute frame Difference (MAD)

$$MAD = \frac{1}{I*J}\sum_{i=1}^{I}\sum_{j=1}^{J}|f(i,j)-g(i-dx,j-dy)|$$

- Sum of Absolute Difference (**SAD**)

$$SAD = \sum_{i=1}^{I}\sum_{j=1}^{J}|f(i,j)-g(i-dx,j-dy)|$$

Generally, $I = J = 16$

Full Search Method

- Search every point in the searching window
  - Matching: $(2w+1)^2$
  - For each matching, the error computation: $N \times N$
    - If w=16 (the default search range in MPEG-1/2/4), the total number of search points will be 1089.

References

- [1] G. Johansson, "Visual perception of biological motion and a model for its analysis", *Perception and Psychophysics*, vol.14, 201-211, 1973.

- [2] B. Lucas and T. Kanade, "An iterative image registration technique with an application to stereo vision," in Proc. of *International Joint Conf. On Artificial Intelligence*, pp.674-679, 1981.

- [3] B. Horn and B. Schunck, "Determining optical flow," *Artificial Intelligence*, 17:185-203, 1981.

- [4] T. Koga, K. Iinuma, A. Hirano, Y. Iijima, and T. Ishiguro, "Motion compensated interframe coding for video conferencing," *Proceedings of national Telecommunications conference*, New Orleans, LA, pp.G5.3.1–G5.3.5, Dec. 1981.

- [5] R. Li, B. Zeng, and M. L. Liou, "A new three-step algorithm for block motion estimation," *IEEE Trans. On Circuits and Systems for Video Technology*, 4(4): 438-442, 1994.

- [6] L.-M. Po and W.-C. Ma, "A novel four-step search algorithm for fast block motion estimation," *IEEE Trans. On Circuits and Systems for Video Technology*, 6(3): 313-317, 1996.

- [7] S. Zhu and K.-K. Ma, "A new diamond search algorithm for fast block-matching motion estimation," *IEEE Trans. On Image Processing*, 9(2): 287-290, 2000.

Thank You!

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