Video Compression and Coding using Transforms, Subband Filters and Motion Compensation

Laboratory Exercise 2

Multimedia and Video Communications (SSY150)

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Modes of video compression

- Intra Mode
  - also called 2D image compression
  - first generation technique

- Inter Mode
  - between two images or consecutive images
  - 2nd generation technique

INTRA compression mode

- Image consists of **low frequency** (High energy coefficient) and **high frequency** parts (small energy coefficients).

- Edges, textures lie on low frequency parts.

Criteria to use Transformation of images:

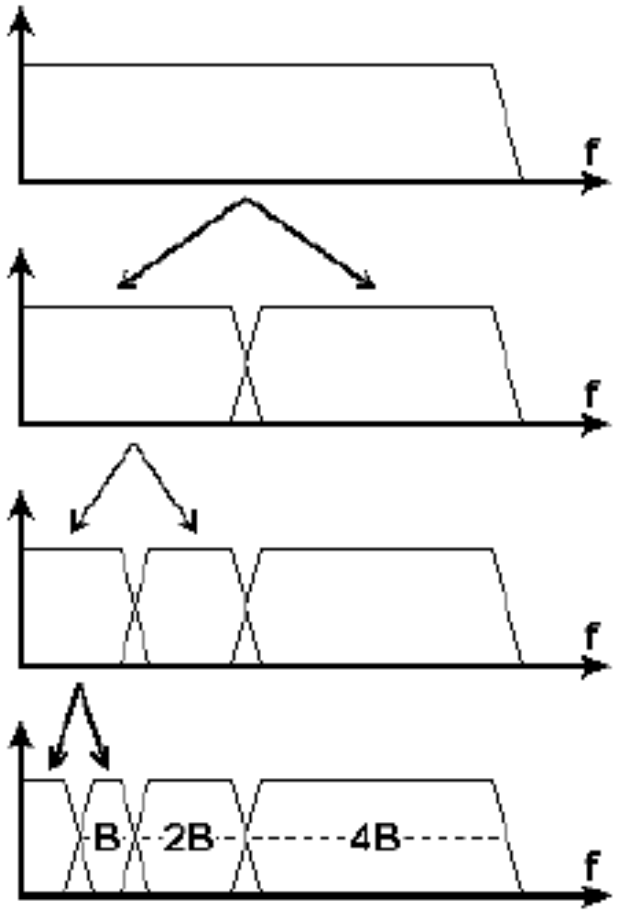
- KLT (expensive computation)
- DCT
- Subband filter

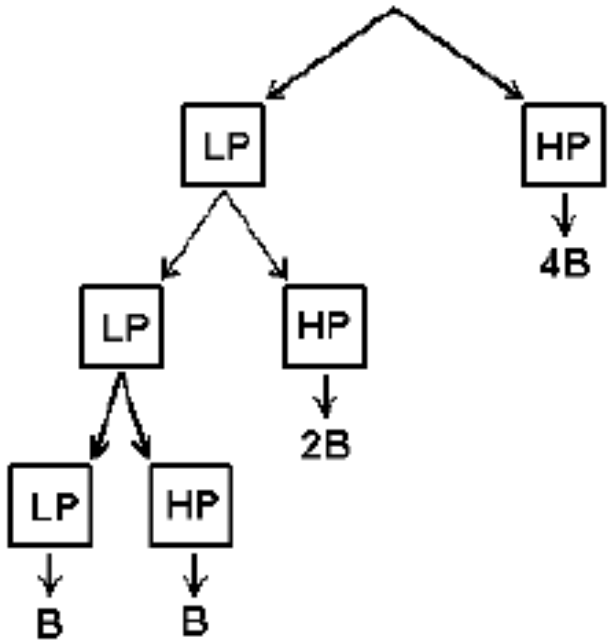
Discret Cosine Transformation (DCT)

- A **discrete cosine transform** (**DCT**) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.

- **Block based DCT**
  - Images are non-stationary
  - For a small area, image block can be considered as stationary.
  - Typical block size (8×8, 16×16 pixels)

1D Subband Filters using Wavelets

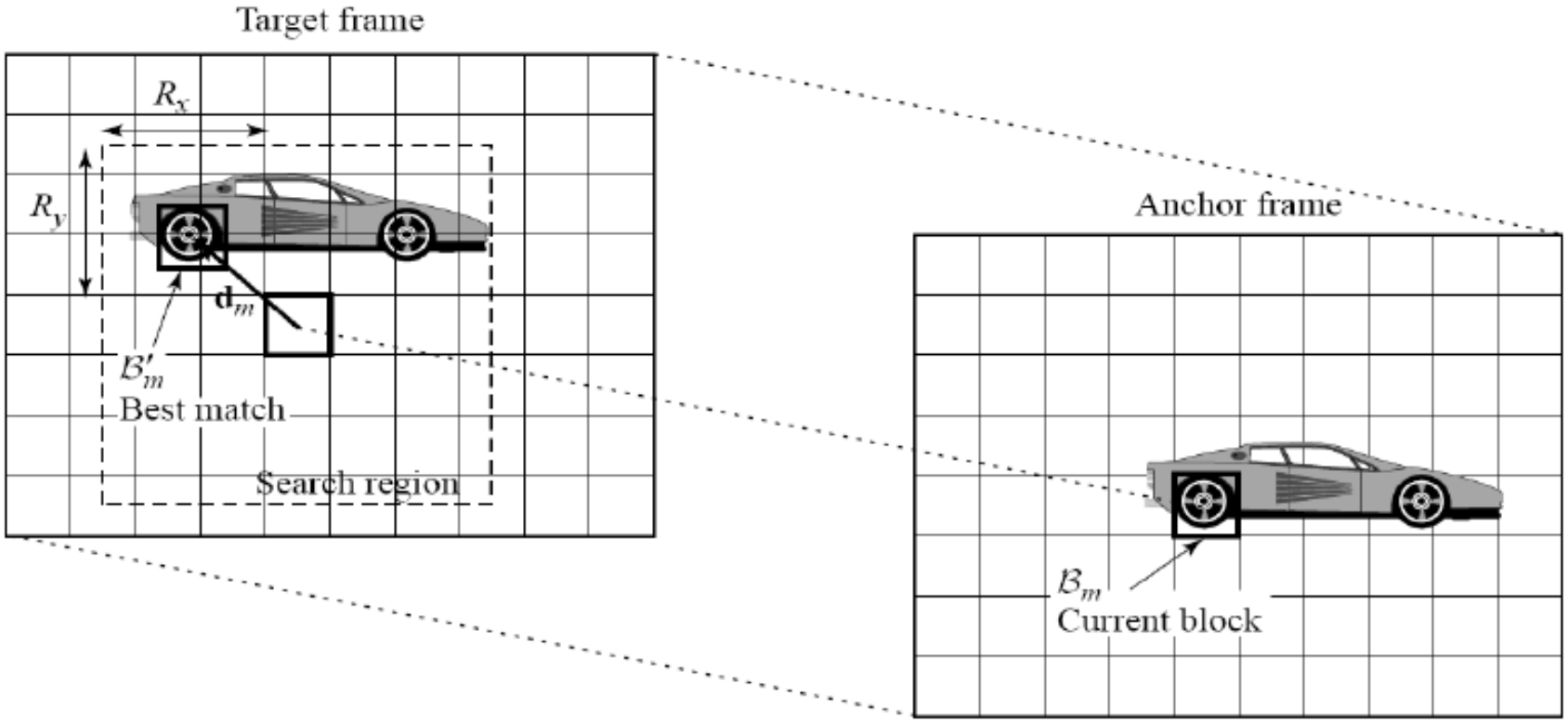




Advantage over DCT:

Avoids block artifacts

Inter-Frame Video Compression based

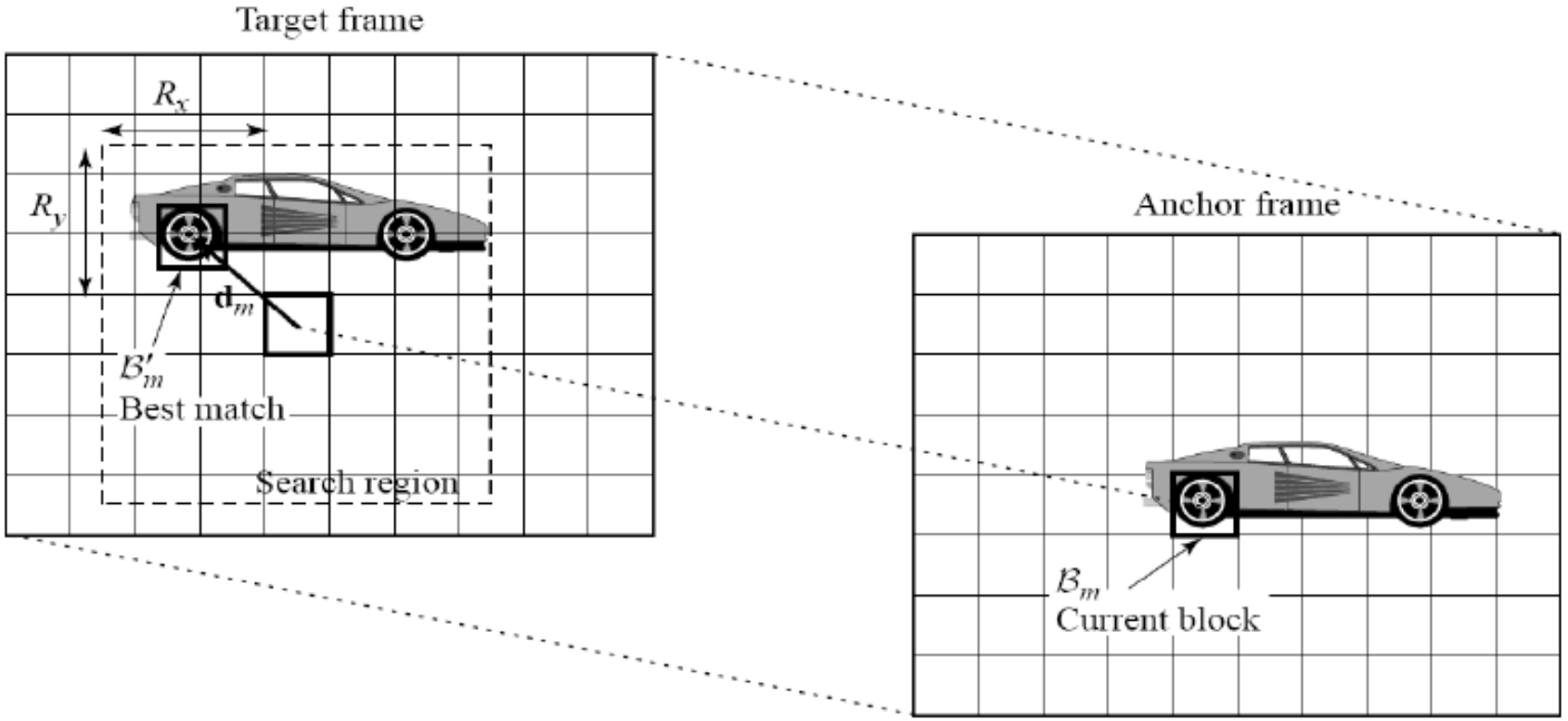


Compute motion vector based on prediction error

$$MSE_{(i,j)}(dx,dy) = \frac{1}{M_x M_y} \sum_{y_j=(j-1)M_y+1}^{jM_y} \sum_{x_i=(i-1)M_x+1}^{iM_x} [\mathbf{I}_t(x_i,y_j) - \mathbf{I}_{t-1}(x_i-dx, y_j-dy)]^2$$

$$1 \le (x_i - dx) \le N_x,\ 1 \le (y_j - dy) \le N_y \text{ (for global search)}$$

Inter-Frame Video Compression based



Compute motion vector
Compute prediction error

$$MAE_{(i,j)}(dx,dy) = \frac{1}{M_x M_y} \sum_{y_j=(j-1)M_y+1}^{jM_y} \sum_{x_i=(i-1)M_x+1}^{iM_x} |\mathbf{I}_t(x_i,y_j) - \mathbf{I}_{t-1}(x_i-dx, y_j-dy)|$$

$$1 \le (x_i - dx) \le N_x,\ 1 \le (y_j - dy) \le N_y \text{ (for global search)}$$

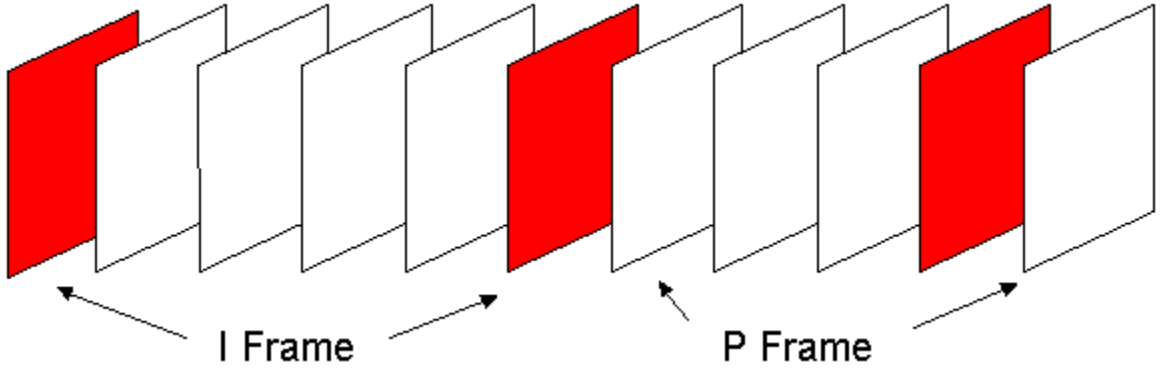
Inter-Frame Video Compression based

- Typical block size (8 by 8, 16 by 16)
- For complex motion, smaller block size is used with more computation.
- Larger block size uses less computation but with larger prediction error.

Video Encoding

- Intra mode (I frames)

- Inter mode(P frame)
  - Motion vector (dx, dy)
  - Motion compensation



Assessing the Quality of Compressed Images

- PSNR

$$PSNR = 10 \cdot \log_{10} \left(\frac{\mathrm{MAX}_{\mathbf{x}}^2}{\mathrm{MSE}} \right)$$

- SSIM

  computes similarity between images.

$$SSIM(\mathbf{x}, \mathbf{y}) = \frac{(2\mu_{\mathbf{x}}\mu_{\mathbf{y}} + c_1)(2\sigma_{\mathbf{xy}} + c_2)}{(\mu_{\mathbf{x}}^2 + \mu_{\mathbf{y}}^2 + c_1)(\sigma_{\mathbf{x}}^2 + \sigma_{\mathbf{y}}^2 + c_2)}$$