

# CSc 461/561

## Multimedia Systems

### Video compression

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Spring 2006

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## Temporal redundancy

- Video is a sequence of images
  - e.g., motion JPEG: M-JPEG
- Correlation between consecutive images
  - “difference” due to object or camera motion



Frame i

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Frame i+1

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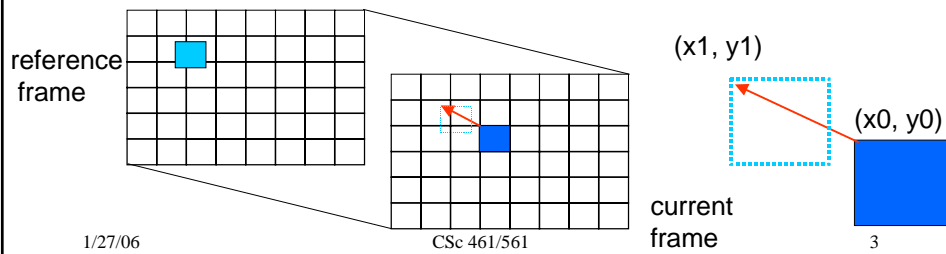


*Direct Difference*

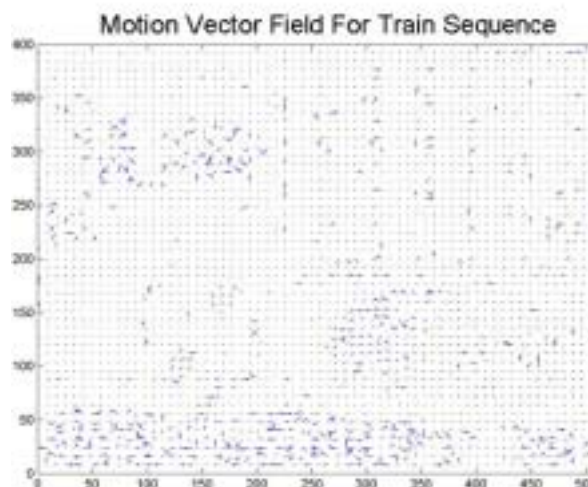
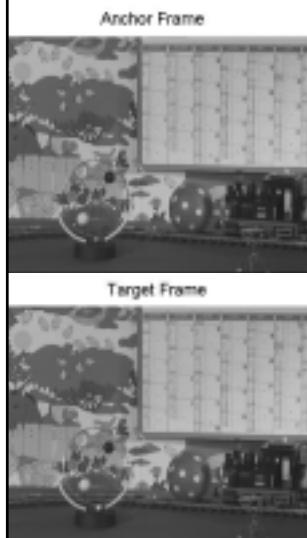
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# Motion estimation

- Macro-block: 16x16 pixels
  - find a *similar* macro-block in the reference frame
  - record the motion “vector”:  $(dx,dy)=(x1-x0,y1-y0)$
  - encode the “difference” between two macro-blocks



# Motion vector example



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## Macro-block similarity

- Similarity measures
  - mean square error (MSE)
  - mean absolute distance (MAD)

$$MAD(i, j) = \frac{1}{N^2} \sum_{k=0}^{N-1} \sum_{l=0}^{N-1} |C(x+k, y+l) - R(x+i+k, y+j+l)|$$

$N$  – size of the macroblock,

$k$  and  $l$  – indices for pixels in the macroblock,

$i$  and  $j$  – horizontal and vertical displacements,

$C(x+k, y+l)$  – pixels in macroblock in Target frame,

$R(x+i+k, y+j+l)$  – pixels in macroblock in Reference frame.

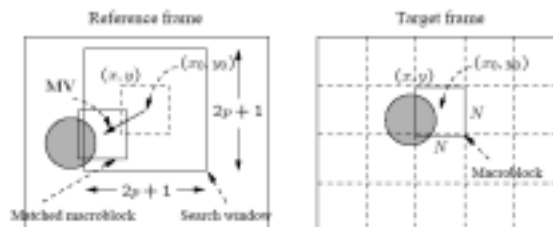
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## Search window

- Rectangle:  $x: [x_0-p, x_0+p]$ ;  $y: [y_0-p, y_0+p]$
- $(2p+1)^2$  all possible reference macro-blocks
  - need *better* search algorithms!

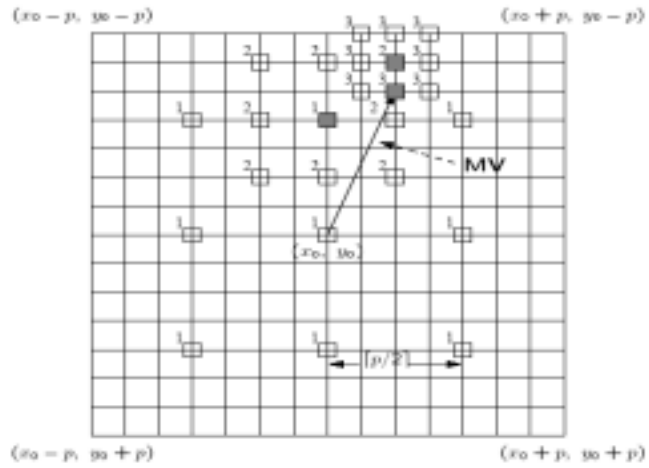


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## 2-D Log motion search

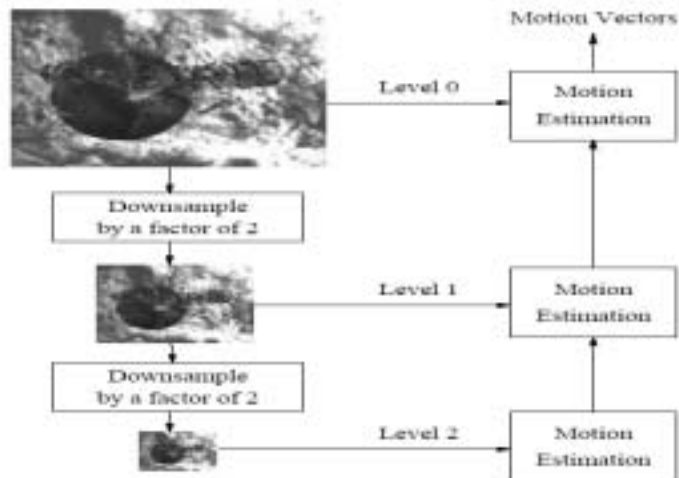


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## Hierarchical motion search



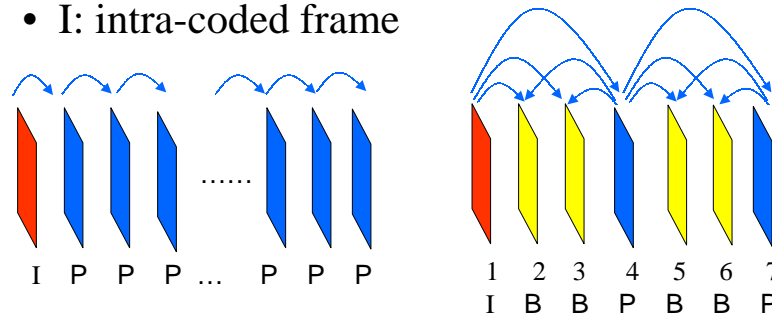
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# Group of pictures

- B: bidirectionally interpolated frame
- P: predicted frame
- I: intra-coded frame

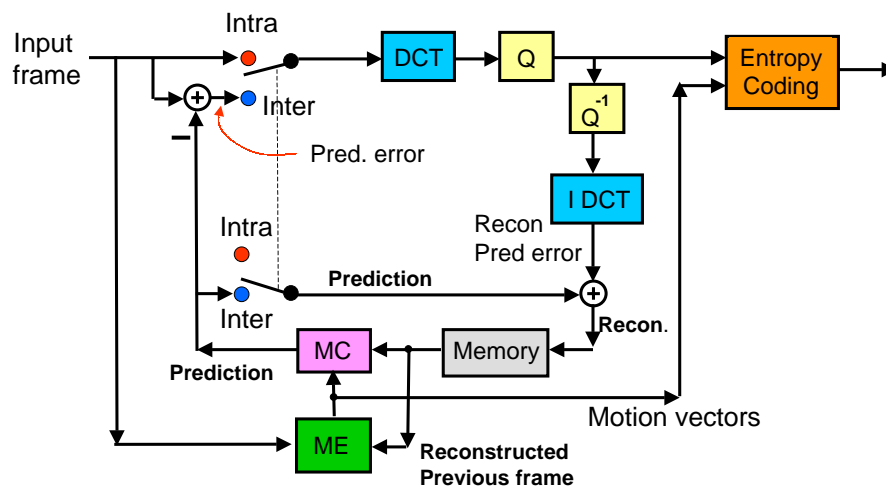


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# Video encoder



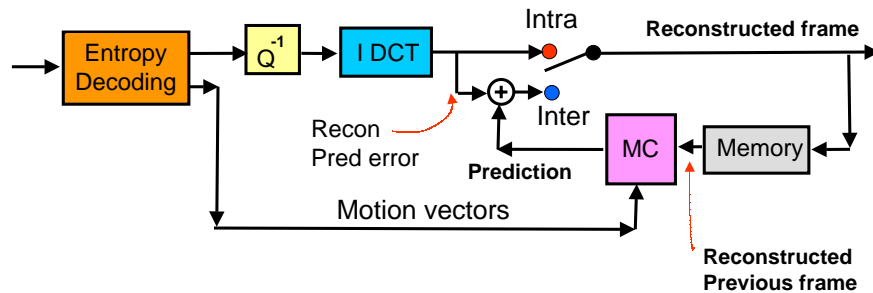
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## Video decoder

- Decoder is simpler than encoder
  - usually only the decoder is standardized
  - allow innovations at encoders



## H.261

- H.261:  $p \cdot 64\text{Kbps}$  ( $p: 1 \sim 30$ )
  - ITU-T recommendation (1990)
  - real-time video telephony over ISDN (2B+D)
    - end-to-end delay less than 150ms
  - QCIF (required): 176x144, 4:2:0, ~30fps, 3 GOB
  - CIF (optional): 352x288, 4:2:0, ~30fps, 12GOB
  - GOB: group of 3x11 macro-blocks
    - 1 macro-block: 4 Y block, 1 Cr block, 1 Cb block
    - 1 block: 8x8 pixel (e.g., in luminance)

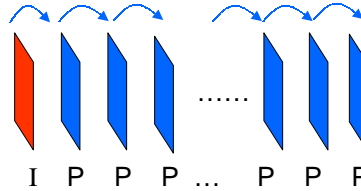
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## H.261: more

- I-frame (JPEG-like)
  - RGB=>YUV, 8x8 blocks
  - DCT
  - Scalar quantization
  - ZigZag scanning, DC/AC encoding, entropy encoding
- P-frame
  - search window  $p=15$
  - pixel precision



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## H.263

- H.263: initially < 64Kbps; later higher bps
  - ITU-T Rec (1995); v2(1998); v3 (2000)
- More video formats
  - sub-QCIF, QCIF, CIF, 4CIF, 16CIF
- More motion estimation techniques
  - half-pixel precision
  - modes: unrestricted motion vector, arithmetic coding, advanced prediction, PB-frames, etc

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## This lecture

- Video compression
  - motion vector
    - how to find a similar macro-block
  - generic video encoder/decoder
  - examples: H.261/263
- Explore further
  - H.263v2 (H.263+) and H.263v3 (H.263++)

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## Next lecture

- Multimedia manipulation
  - video compression standards  
[Ref: Li&Drew Chap 11-12]
    - MPEG-1/2/4 [11.2-3, 12.1-2]
    - H.264 [12.5]

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