COL783: Digital Image Processing

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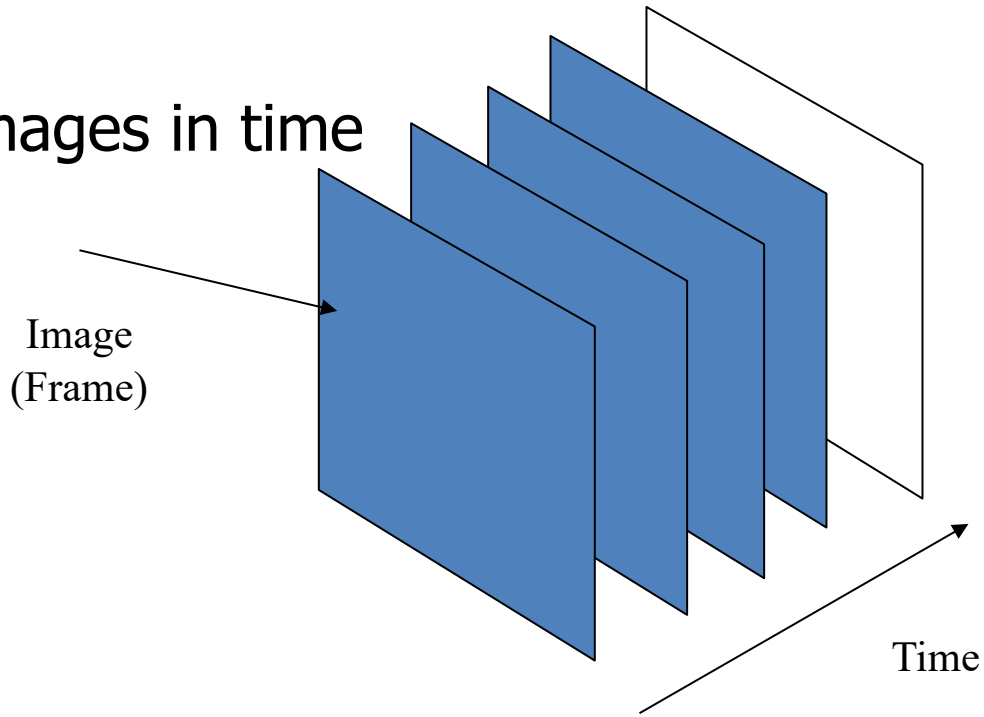
Video Compression

Digital Video

Video is a sequence of images in time

- can be edited
- can be stored on any digital medium
- can be compressed



Video Compression

- The Need for Video Compression
- Huge data
- Example: High-Definition Television (HDTV)
- 1920x1080
- 30 frames per second (full motion)
- 8 bits for each three primary colors →Total 1.5 Gb/sec!
- Channel bandwidth 19.2 Mb/sec
- Reduced to 18 Mb/sec w/audio + control …

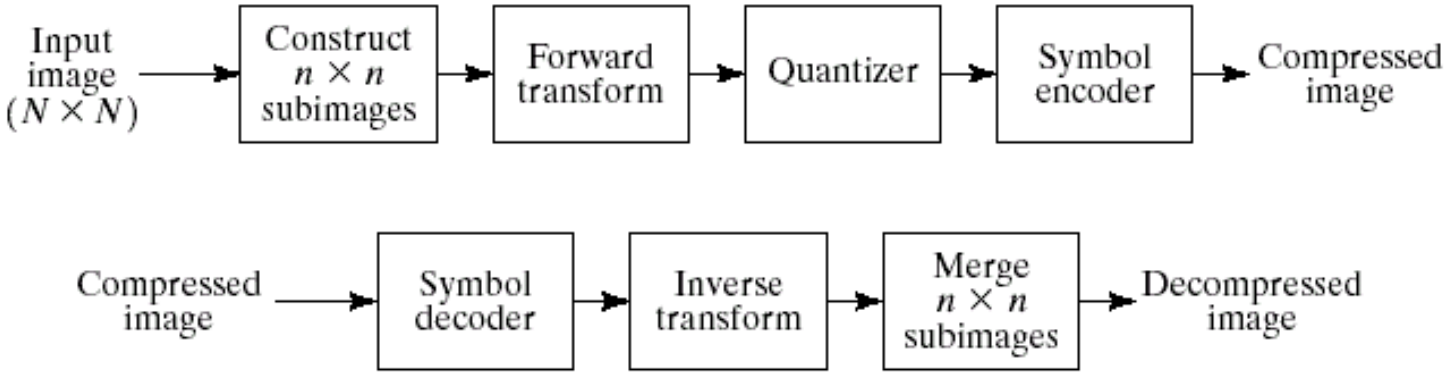
→Compression rate must be 83:1!

Video Compression

Image Compression: Transform Coding-> JPEG

Pipeline

Compression



Decompression

Video Compression

MJPEG (Motion JPEG)

- Each frame can be compressed as single image.
- Compression is achieved only due to the spatial redundancy in the frame.
- Takes care of intra-frame redundancy

Video Compression

Anything else that can be done?

- What about temporal redundancy or inter frame redundancy?

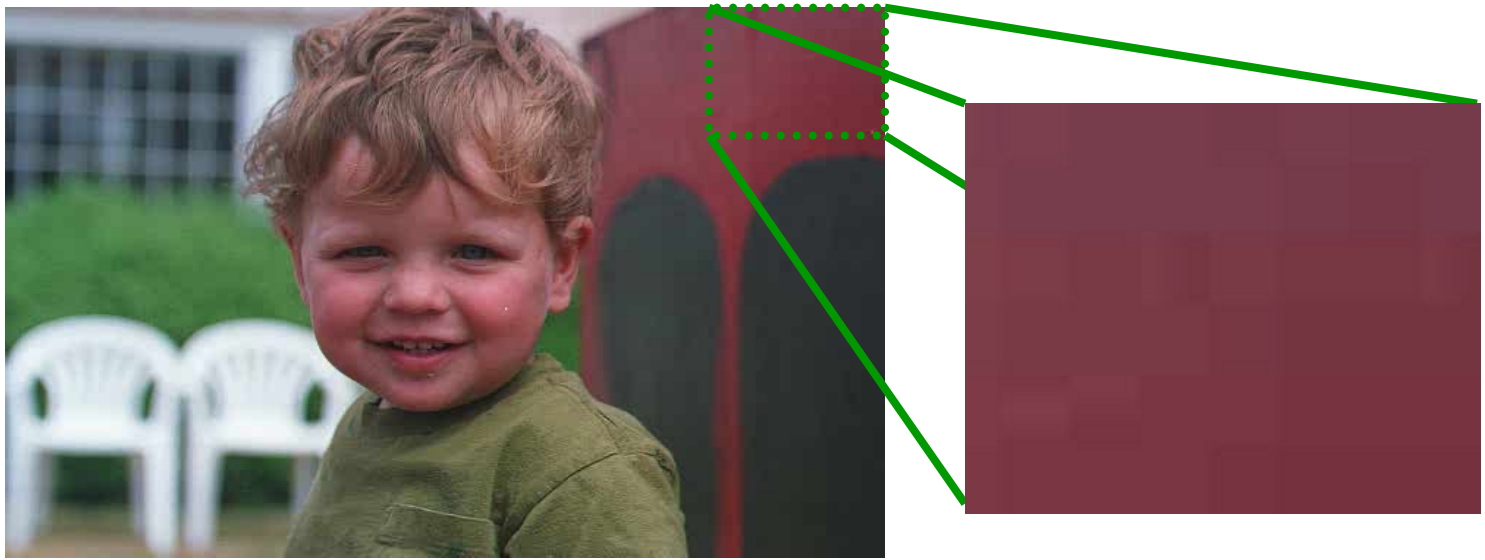
MPEG (Motion Picture Experts Group)

- What about irrelevancy – perceptually unimportant?

Video Compression

Spatial Redundancy

Take advantage of similarity among most neighboring pixels



Video Compression

Temporal Redundancy

Video: Sequence of images in time (that are related!)

Take advantage of similarity between successive frames

950

951

952

Video Compression

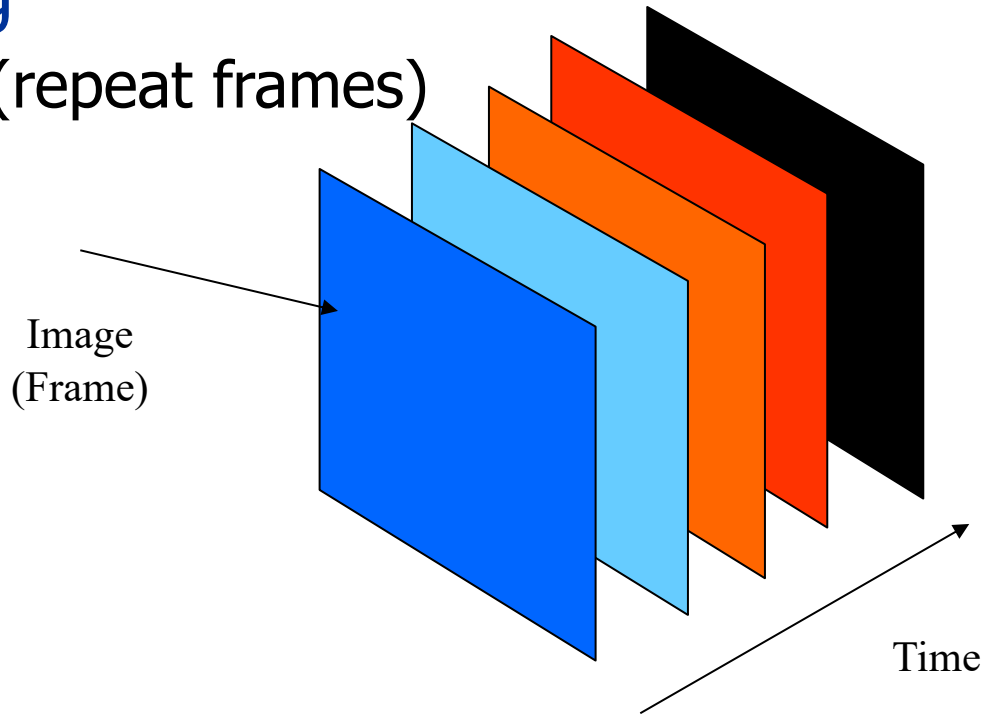
Intuitive Methods

- Subsampling
  - Drop frames
- Differencing
  - Differential coding of pixels
- Block Differencing
  - Differential coding of blocks (big pixels)
- Motion Compensation
  - Figure out the motion vector and compensate for it

Video Compression

Subsampling

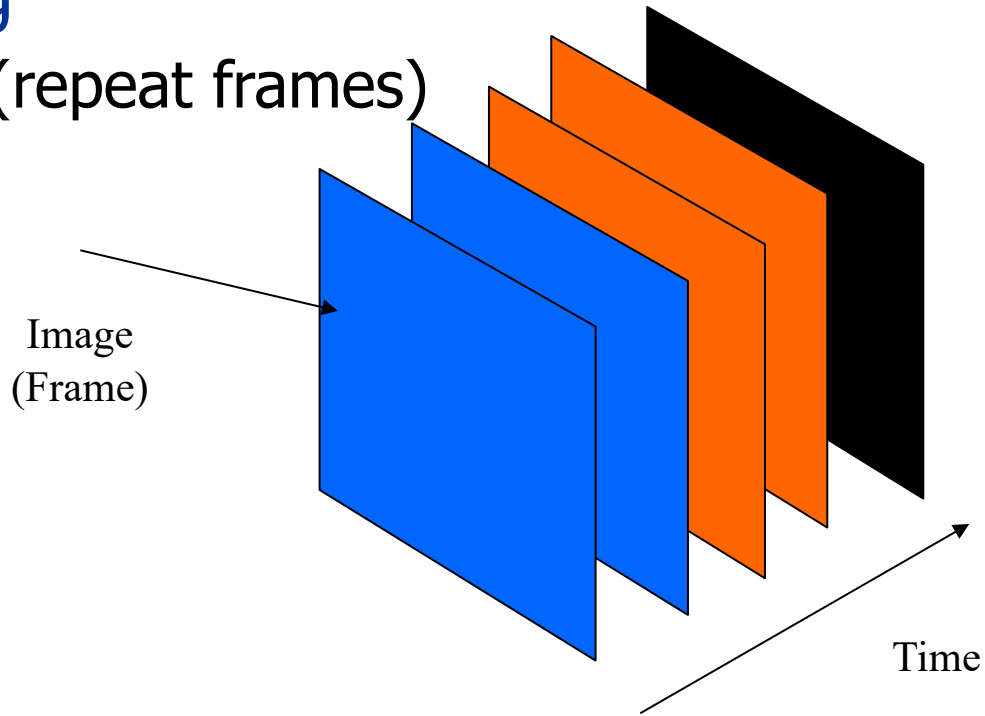
Drop frames (repeat frames)



Video Compression

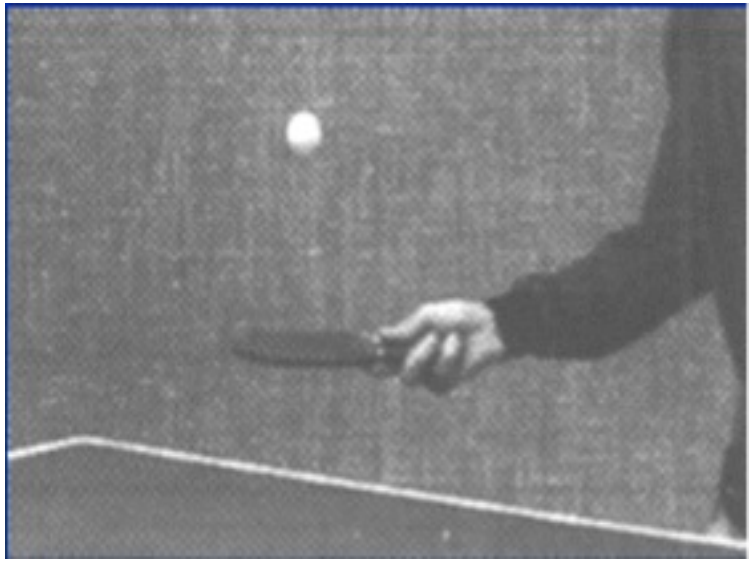
Subsampling

Drop frames (repeat frames)

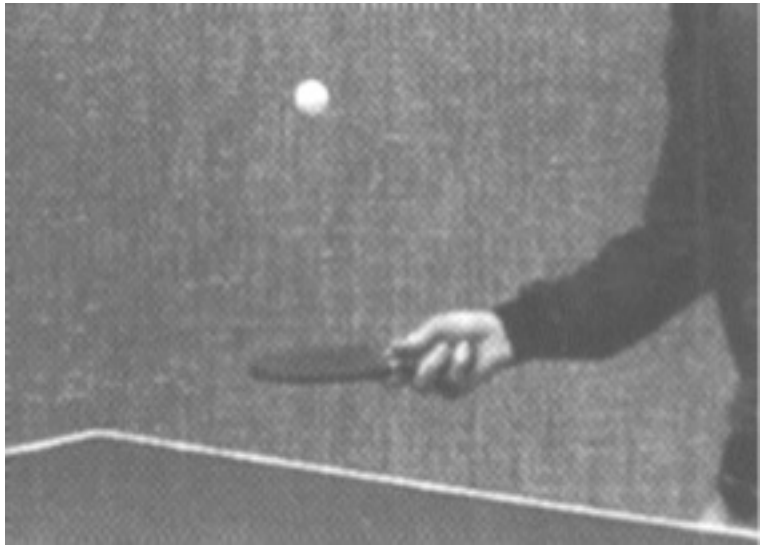


Video Compression

Differencing



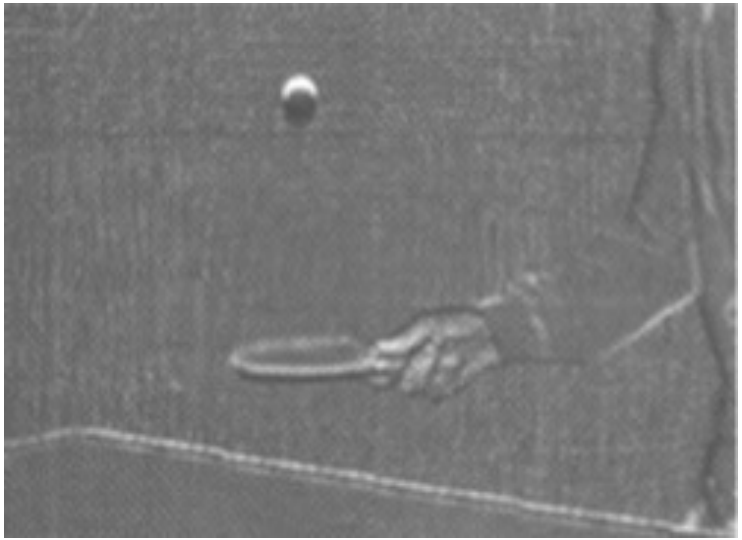
Frame N



Frame N+1

Video Compression

Differencing

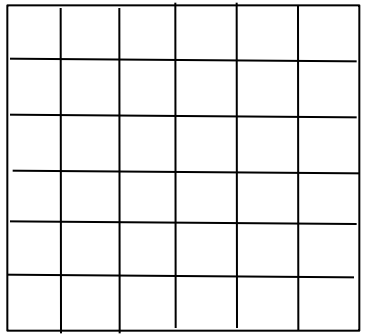


Difference frame

Video Compression

Block Differencing

- Frame is divided into non-overlapping blocks
- Block level comparison rather than pixel level to decide which blocks for the difference is to be coded
- May work when the motion is relatively small of foreground objects
- If the motion is large and not limited to portion of image then it may not be effective



Video Compression

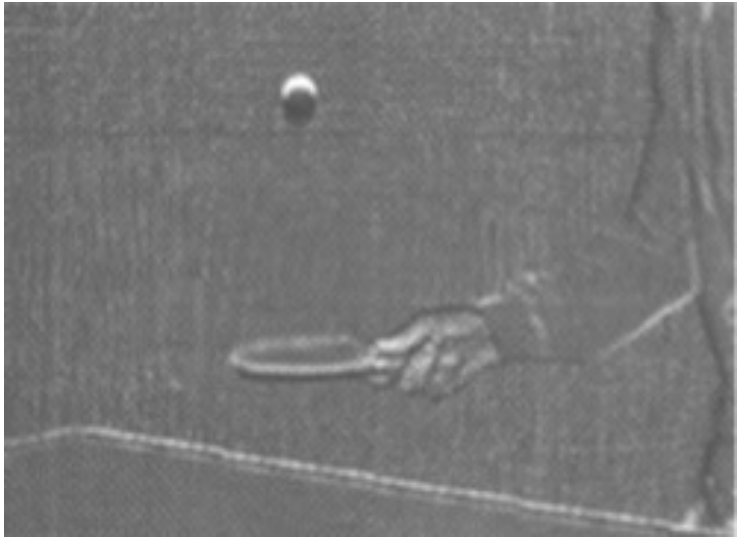
Motion Compensation

- Simple frame difference will fail if there is a significant motion
- Should account for the motion

  Motion-compensated (MC) prediction
- How can we estimate motion?

Video Compression

Motion Compensation



Difference frame without motion prediction

Difference frame with motion prediction

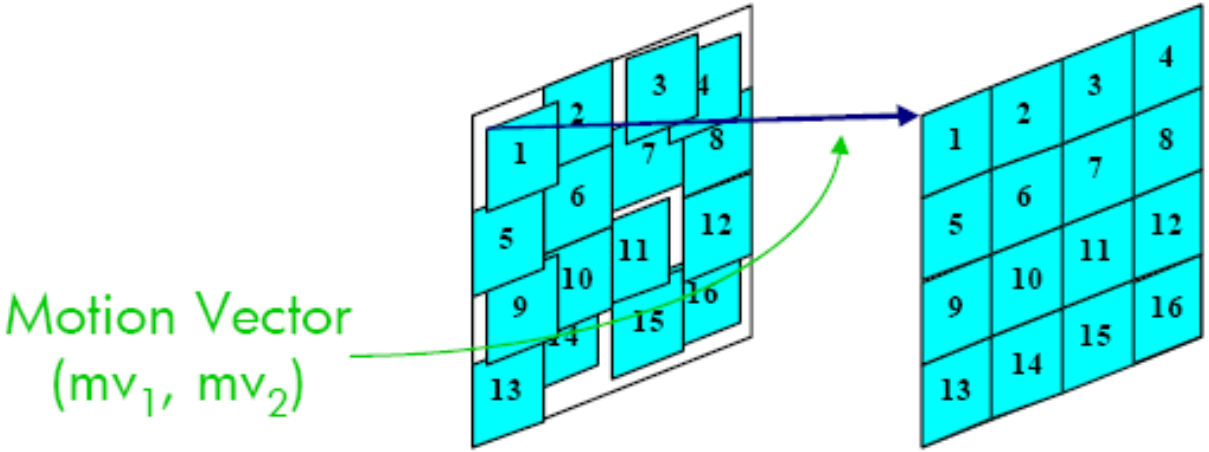
Video Compression

Motion Estimation

- A possible approach
  - Segment video into moving objects
  - Describe (model) object motion
  - May be some what difficult
- Another (practical) approach
  - Block matching motion estimation
  - No object segmentation and identification required
  - Good performance

Video Compression

Motion Estimation



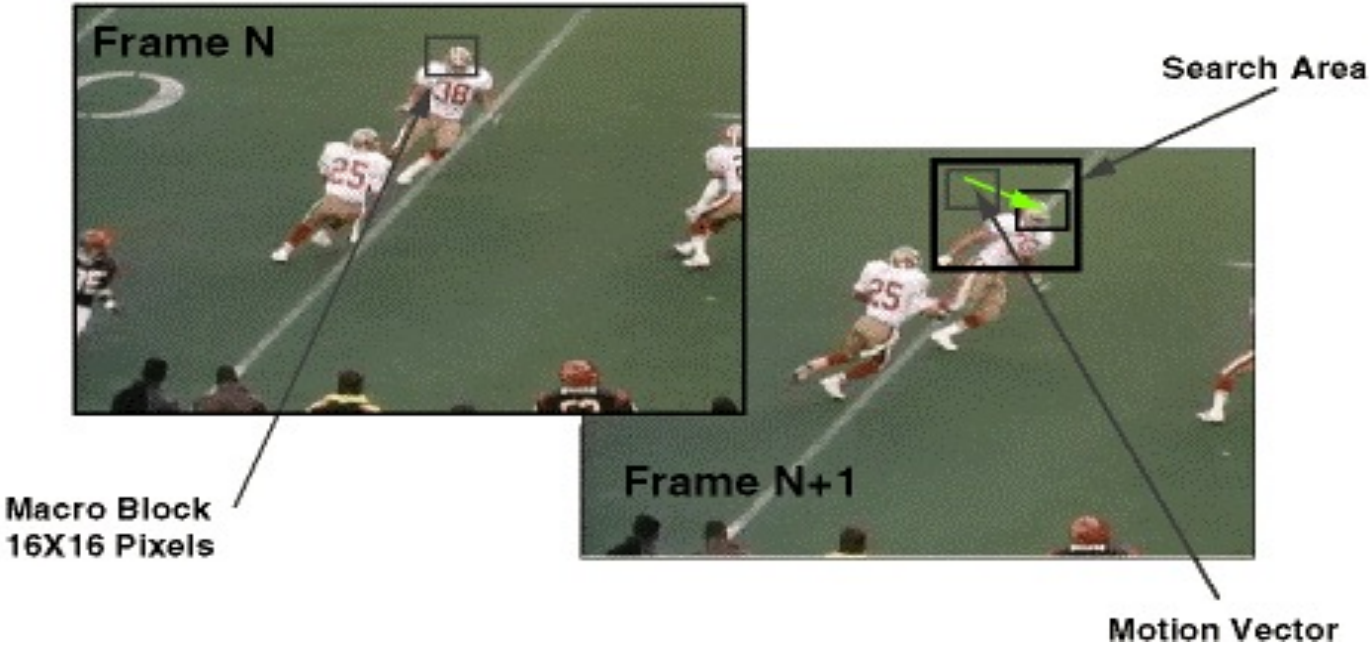
Video Compression

Motion Estimation

- Translation motion model
- All pixels within the block have the same motion
- Motion is estimated using only luminance
- The motion vector is encoded in place of the target block itself.
- Fewer bits are required to code a motion vector

Video Compression

Motion Compensation



Video Compression

Motion Estimation

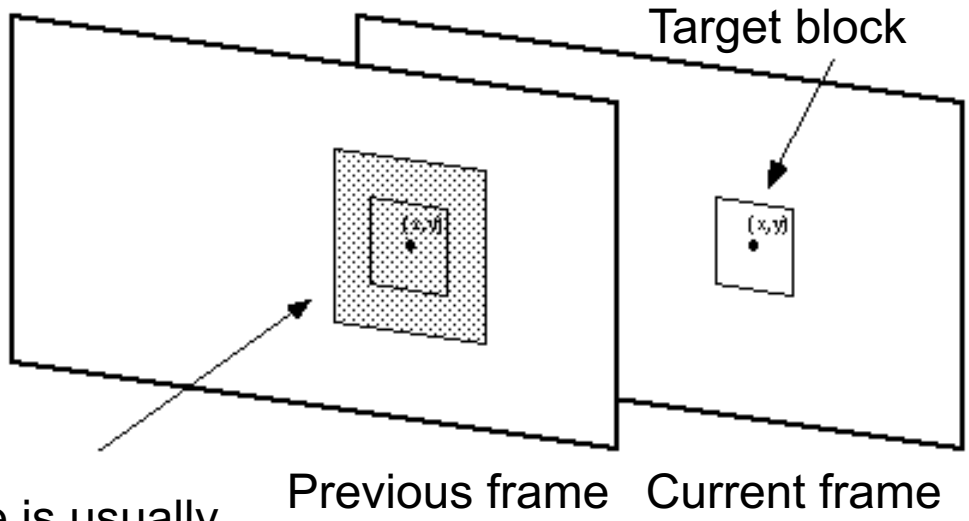
Issues:

Block size ?

Search range ?

Motion vector accuracy ?

Complex motion ?

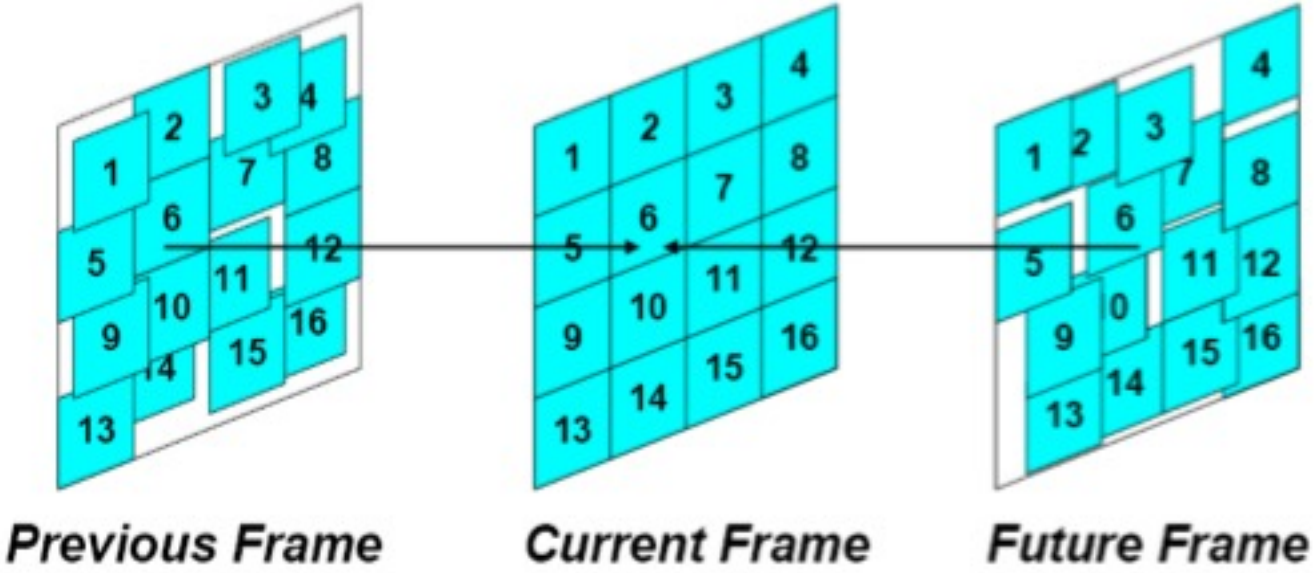


Search area in previous frame is usually limited to a region close to the target block

Video Compression

Motion Estimation

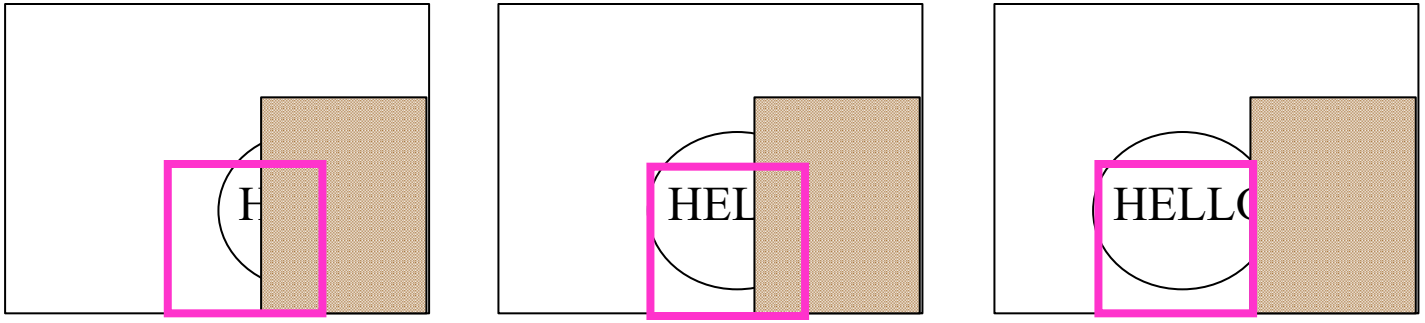
Forward, Backward, Bidirectional



Video Compression

Motion Estimation

Example



Frame N-1 Frame N Frame N+1

Video Compression

Motion Estimation

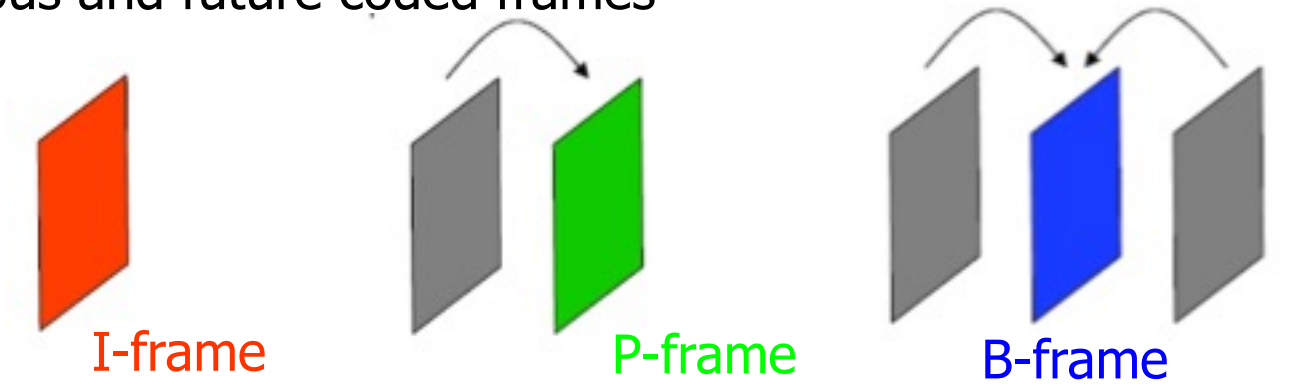
As a general scheme a block in current frame can be estimated from a block in

- Previous frame
- Future frame
- Average of a block from the previous frame and a block from the future frame
- Neither (no prediction)

Video Compression

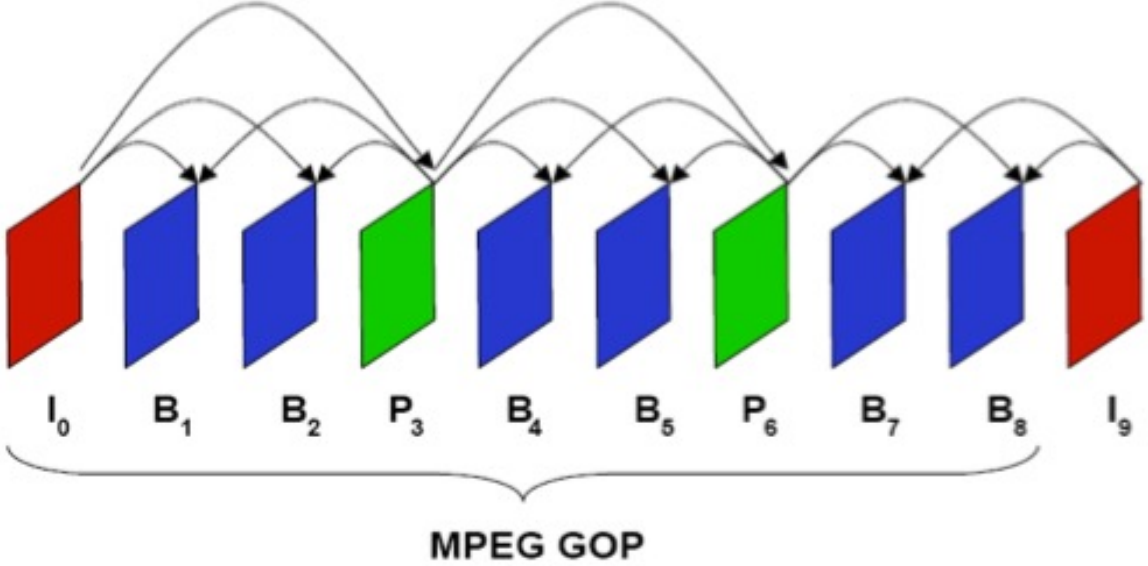
Three types of coded frames

- I-frame: Intra coded frame, coded independently
- P-frame: Predicitve coded frame, coded based on previously coded frame
- B-frame: Bi-directionally predicted frame, coded based on previous and future coded frames



Video Compression

Three types of coded frames

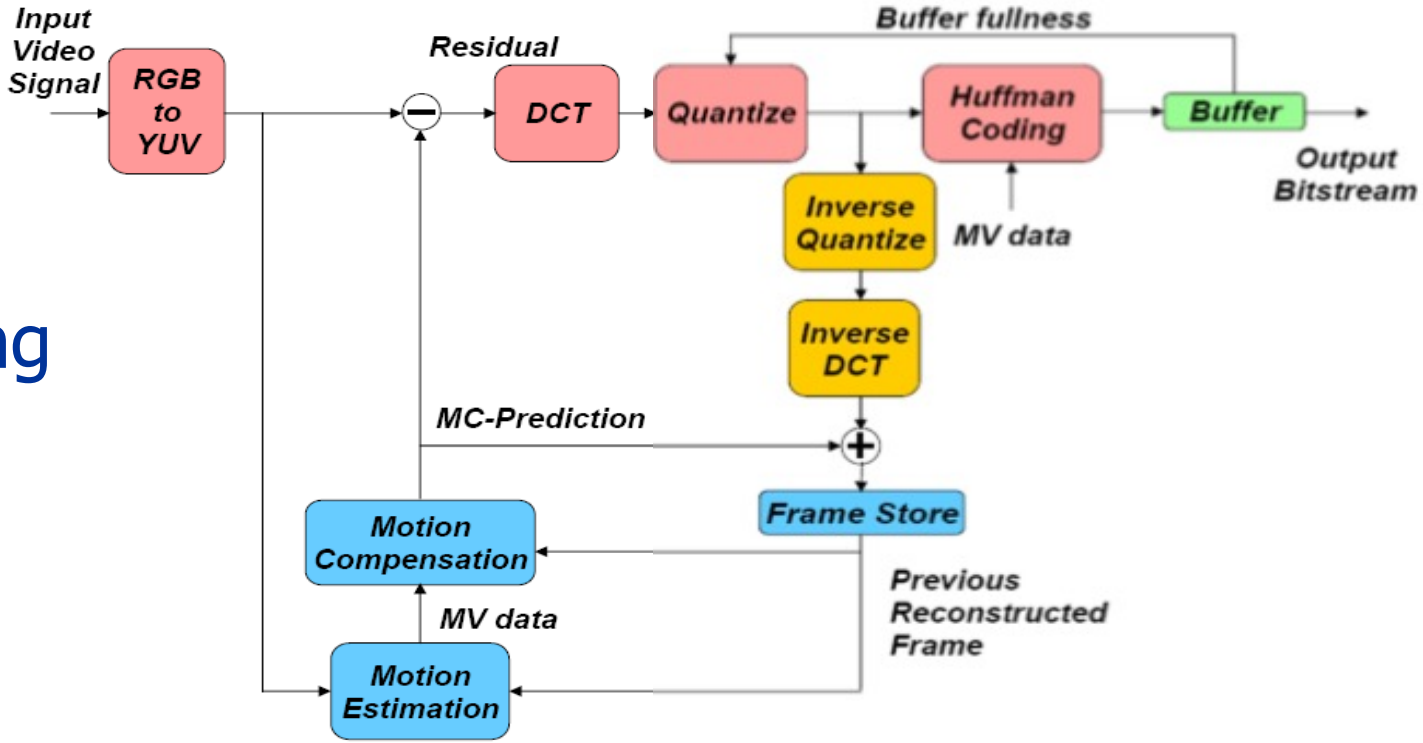


Display order: I_0, B_1, B_2, P_3, B_4, B_5, P_6, B_7, B_8, I_9

Transmission Order: I_0, P_3, B_1, B_2, P_6, B_4, B_5, I_9, B_7, B_8

Video Compression

Encoding



Video Compression

Decoding