



Special Module on Media Processing and Communication

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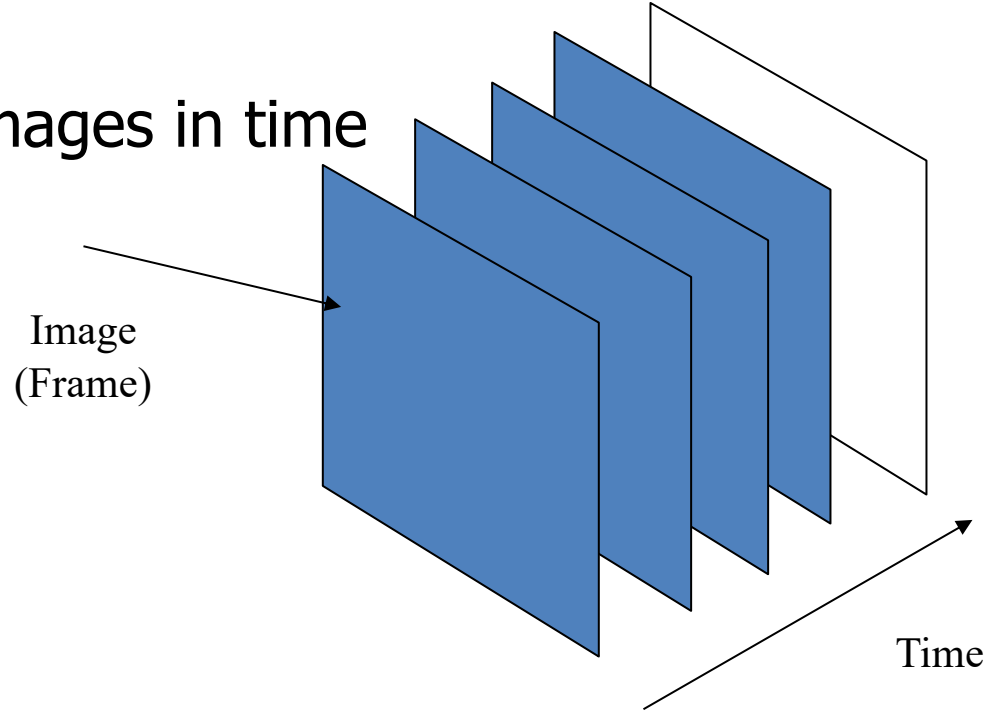


Video Compression

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

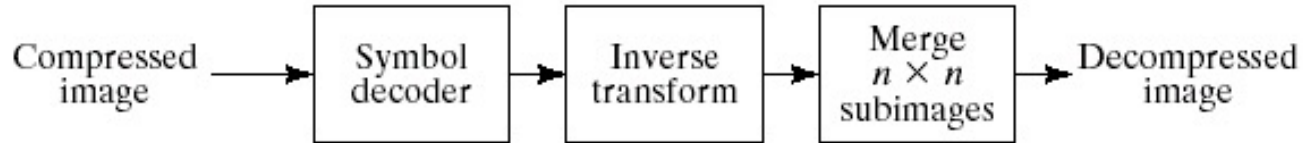
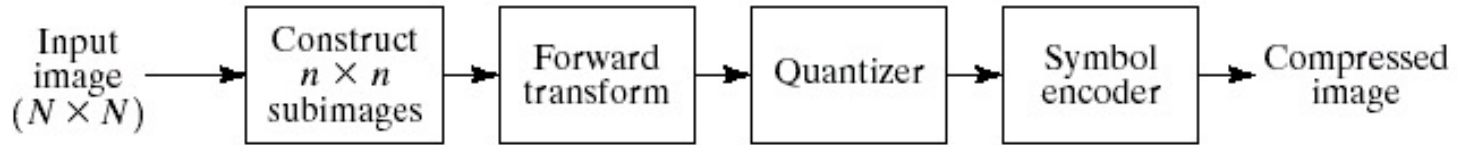
- ▶ The Need for Video Compression
 - Huge data
 - ▶ Example: High-Definition Television (HDTV)
 - 1920x1080
 - 30 frames per second (full motion)
 - 8 bits for each three primary colors → Total 1.5 Gb/sec!
 - Channel bandwidth 19.2 Mb/sec
 - Reduced to 18 Mb/sec w/audio + control ...
- Compression rate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

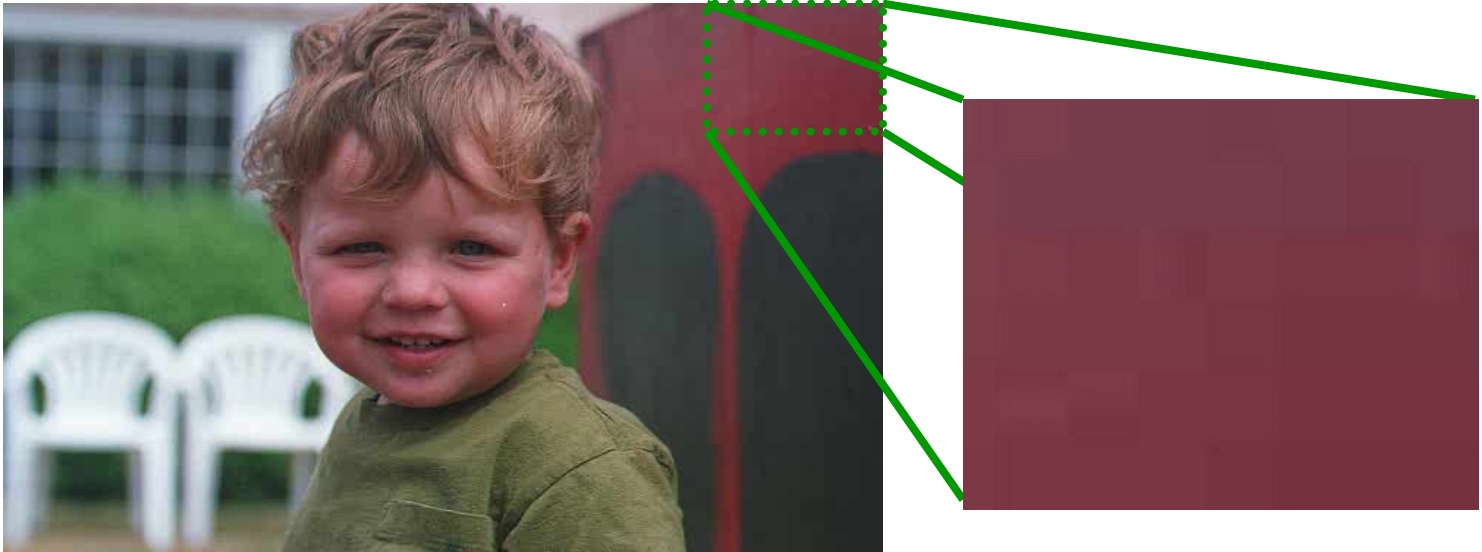
- What about irrelevancy – perceptually unimportant?



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

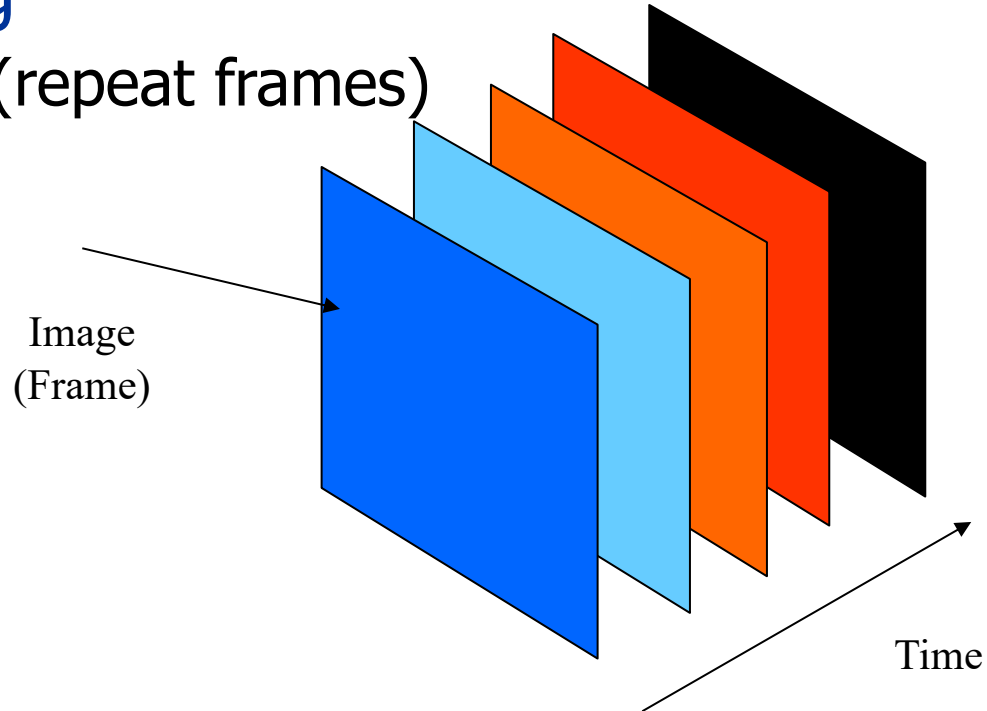
- Subsampling
 - Drop frames
- Differencing
 - Differential coding of pixels
- Block Differencing
 - Differential coding of blocks (big pixels)
- Motion Compensation
 - Figure out the motion vector and compensate for it



Video Compression

Subsampling

Drop frames (repeat frames)

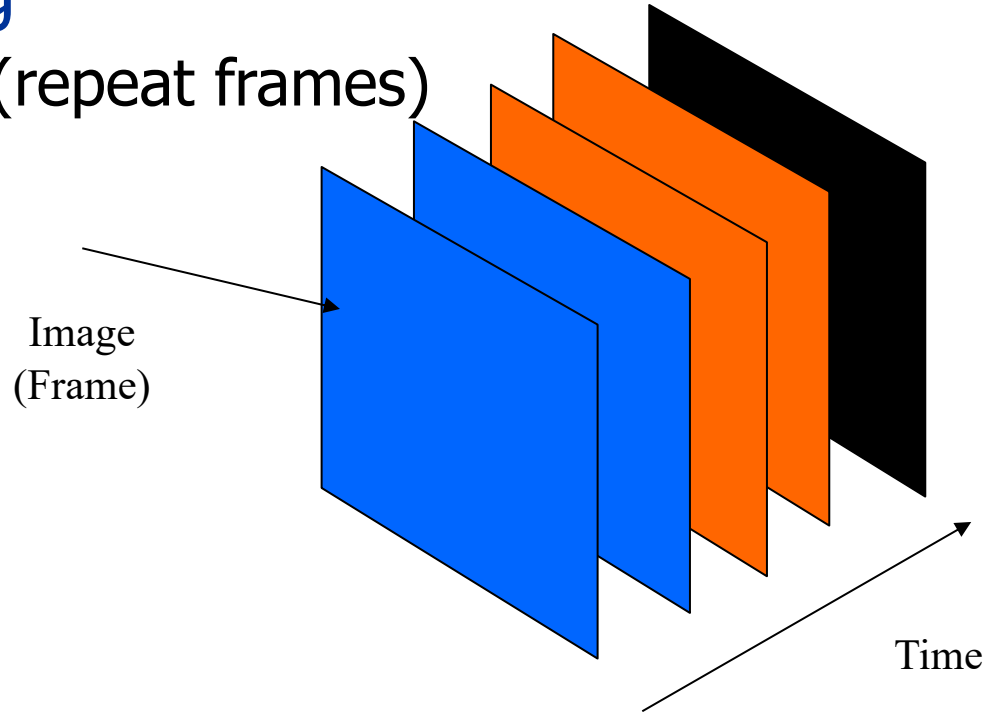




Video Compression

Subsampling

Drop frames (repeat frames)

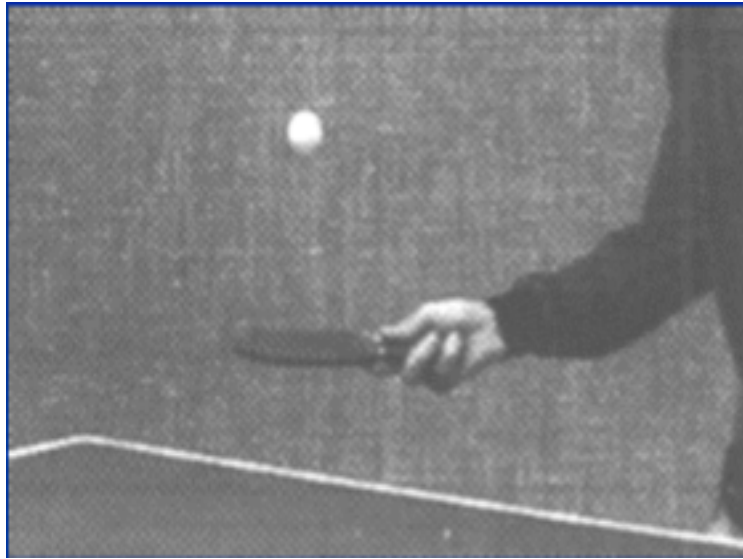




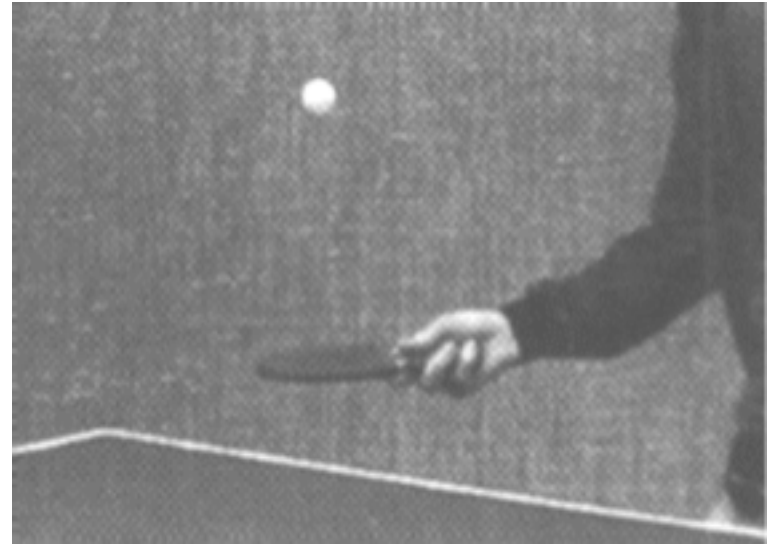
Video Compression



Differencing



Frame N



Frame N+1



Video Compression

Differencing



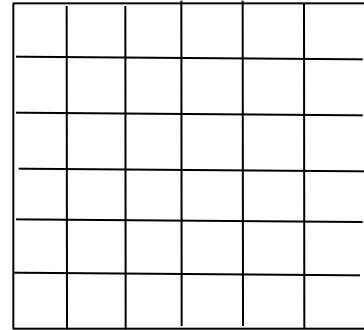
Difference frame



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

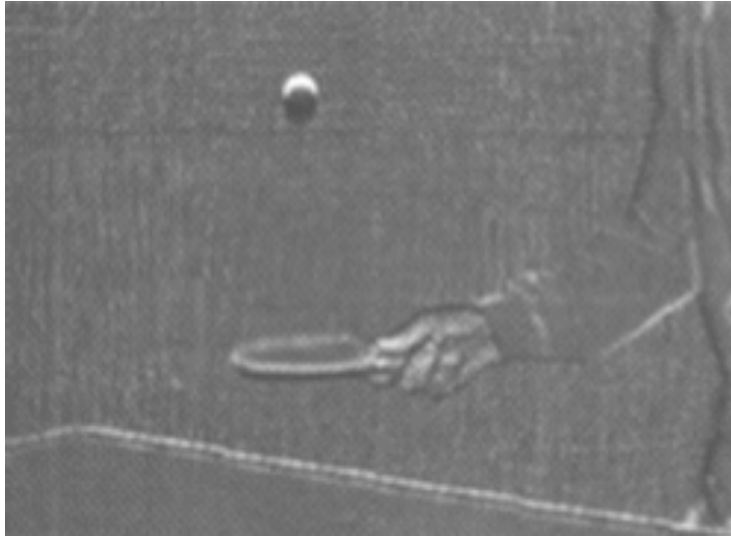
Motion Compensation

- 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

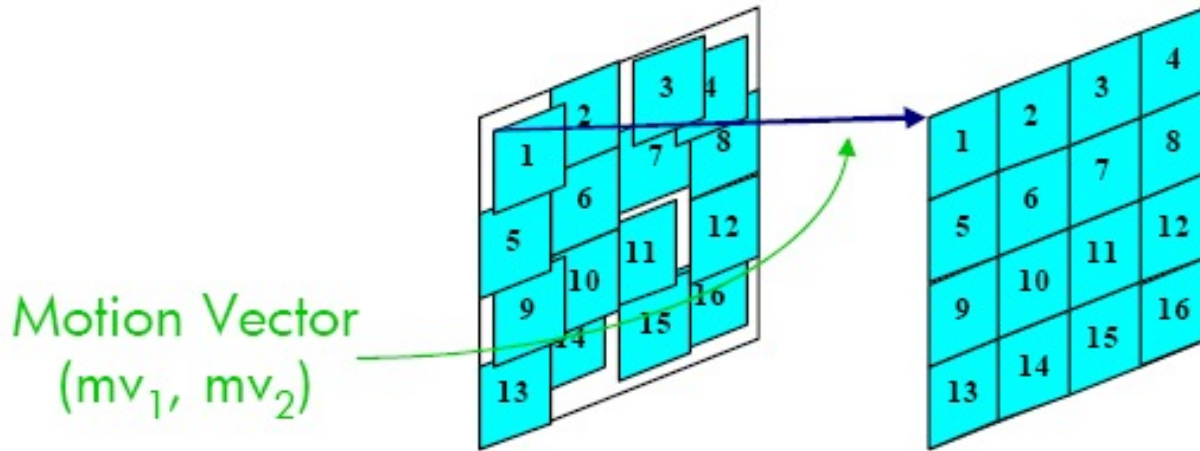
Motion Estimation

- 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

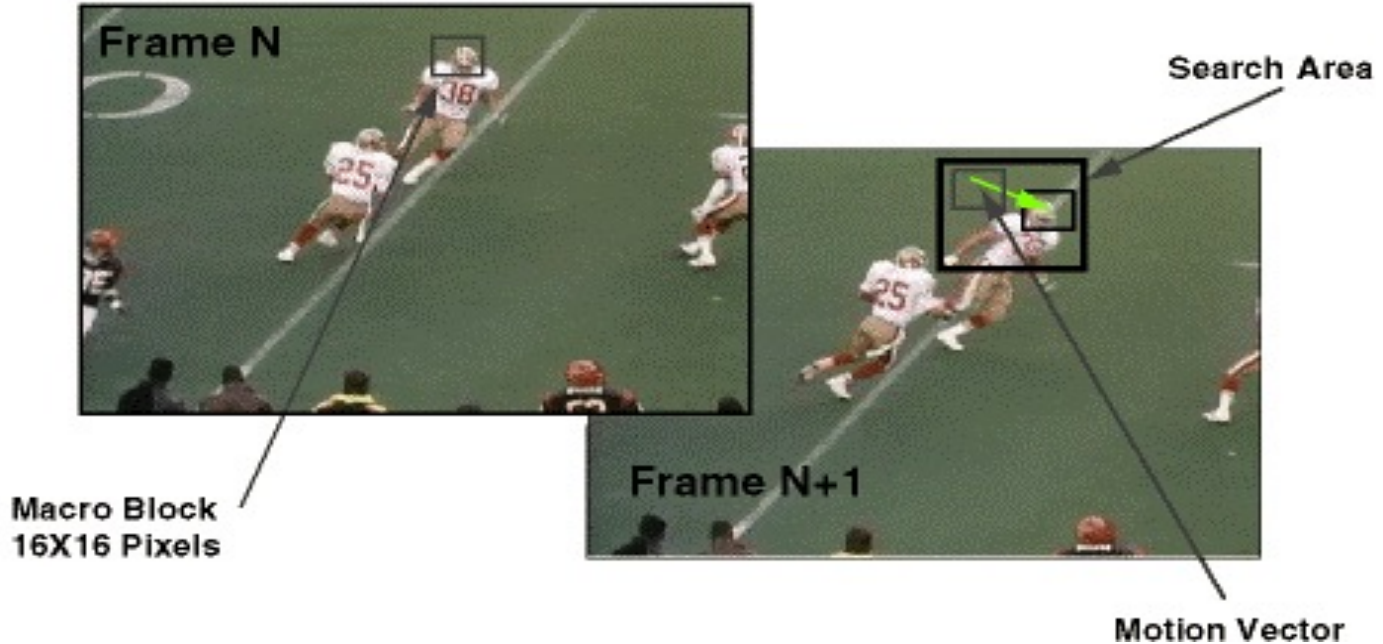
Motion Estimation

- 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:

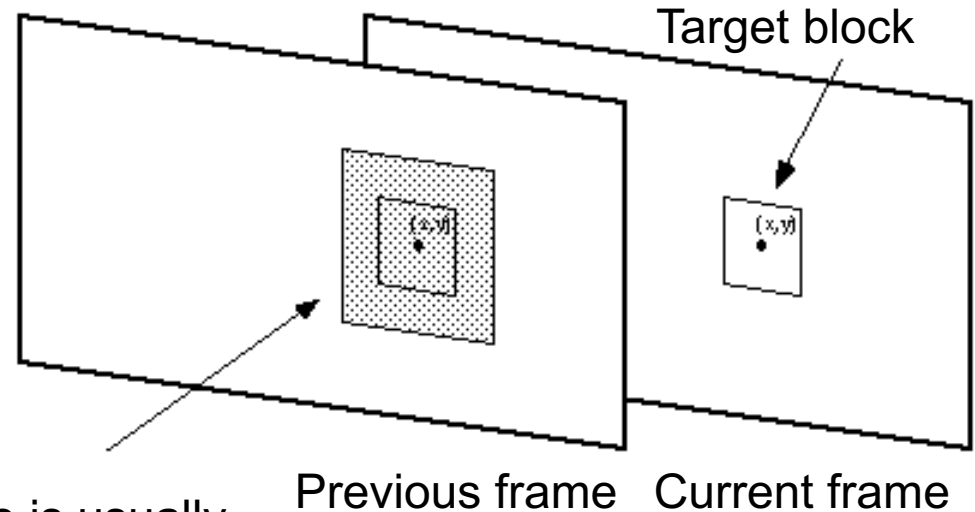
Block size ?

Search range ?

Motion vector accuracy ?

Complex motion ?

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

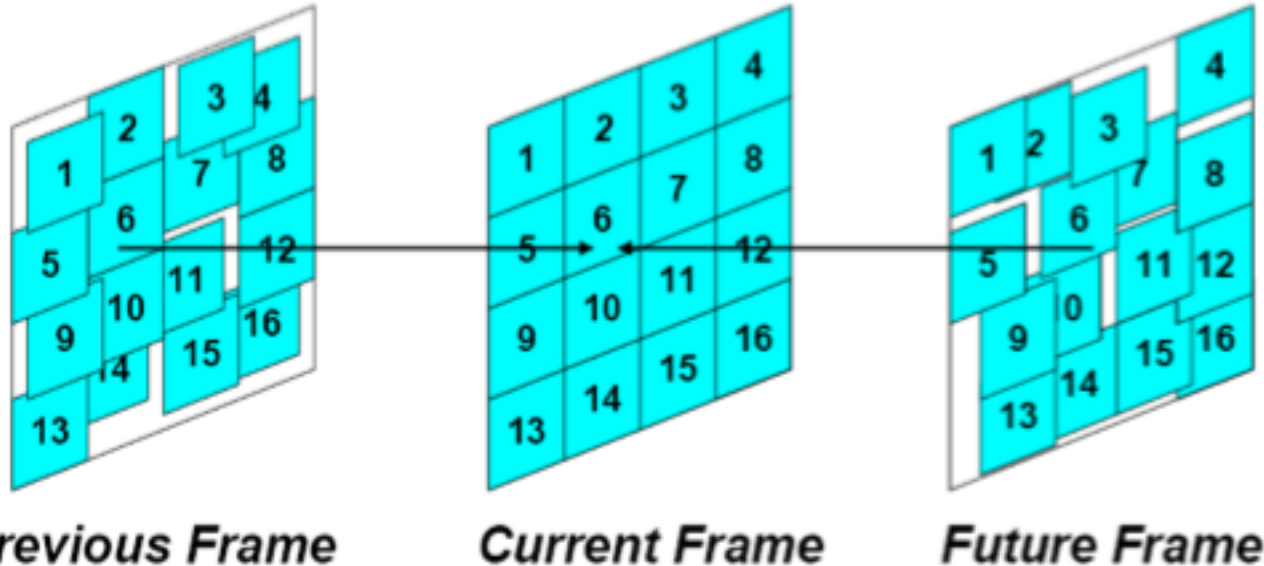




Video Compression

Motion Estimation

Forward, Backward, Bidirectional

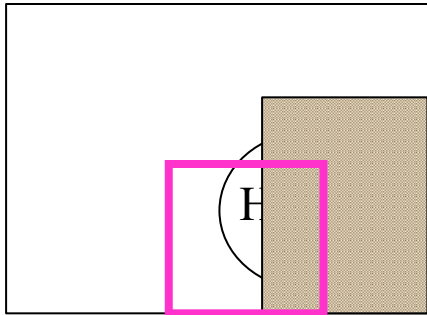




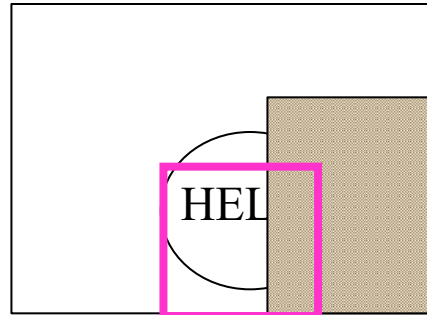
Video Compression

Motion Estimation

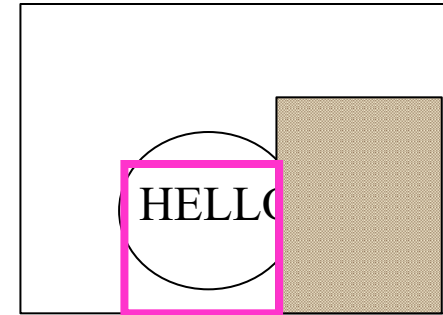
Example



Frame N-1



Frame N



Frame N+1



Video Compression

Motion Estimation

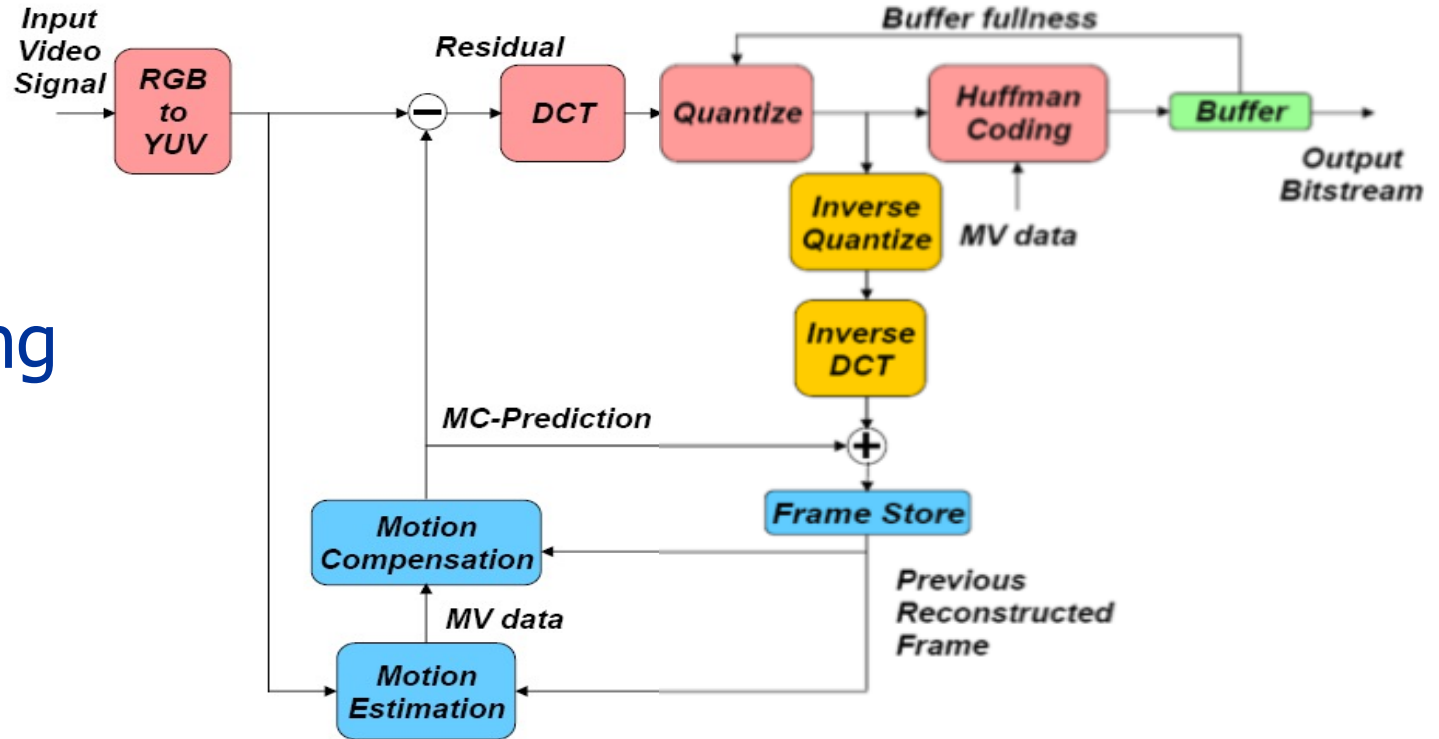
As a general scheme a block in current frame can be estimated from a block in

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



Video Compression

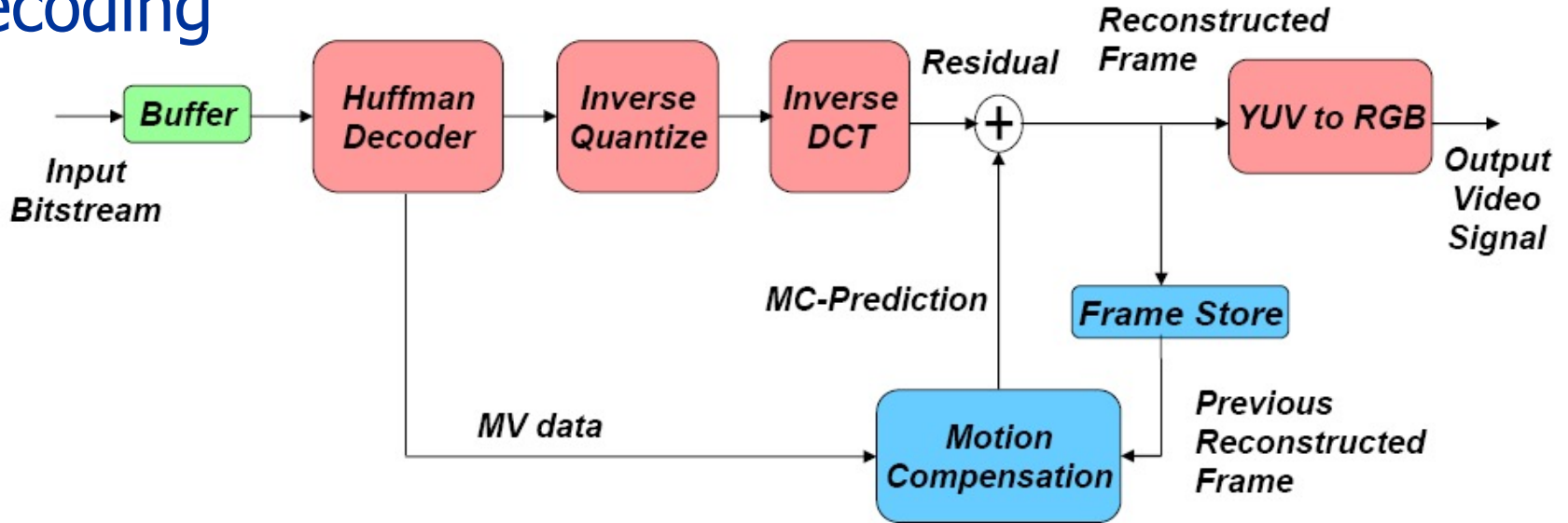
Encoding





Video Compression

Decoding





Video Compression

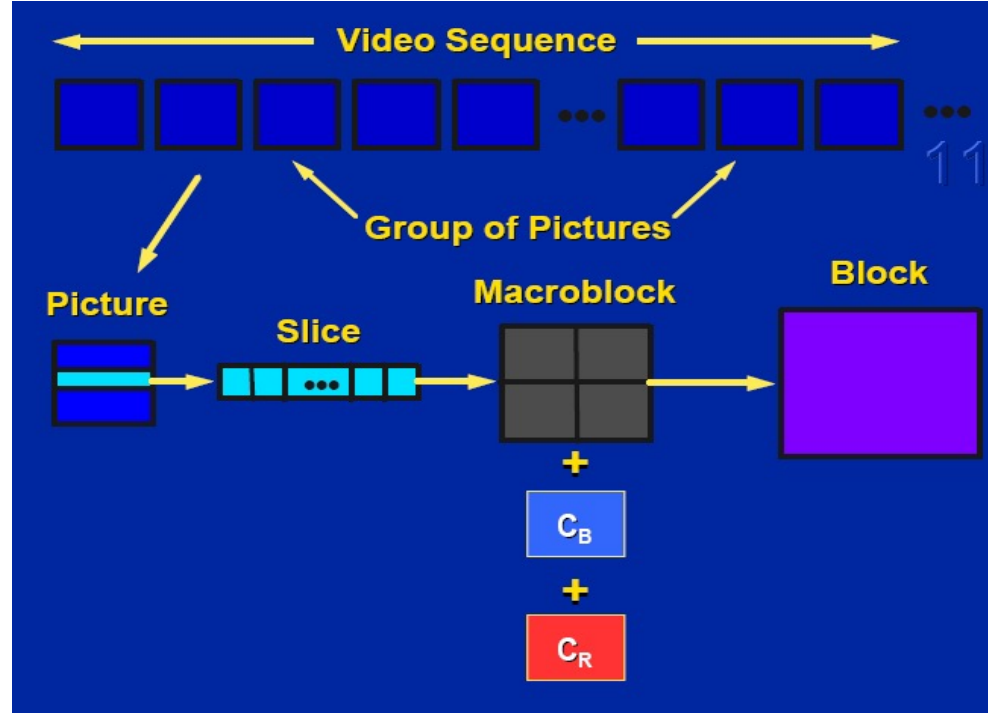
MPEG Standard

- **Block**: A basic unit for DCT operation (8x8)
- **Macroblock**: A basic unit for motion compensation operation (16x16)
- **Slice**: String of macroblocks
- **Picture/Frame**: I/B/P
- **Group-of-pictures (GOP)**: Collection of pictures (10 or so)
- **Video**: Global context unit



Video Compression

MPEG Standard





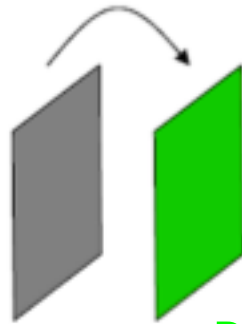
Video Compression

Three types of coded frames

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



I-frame



P-frame

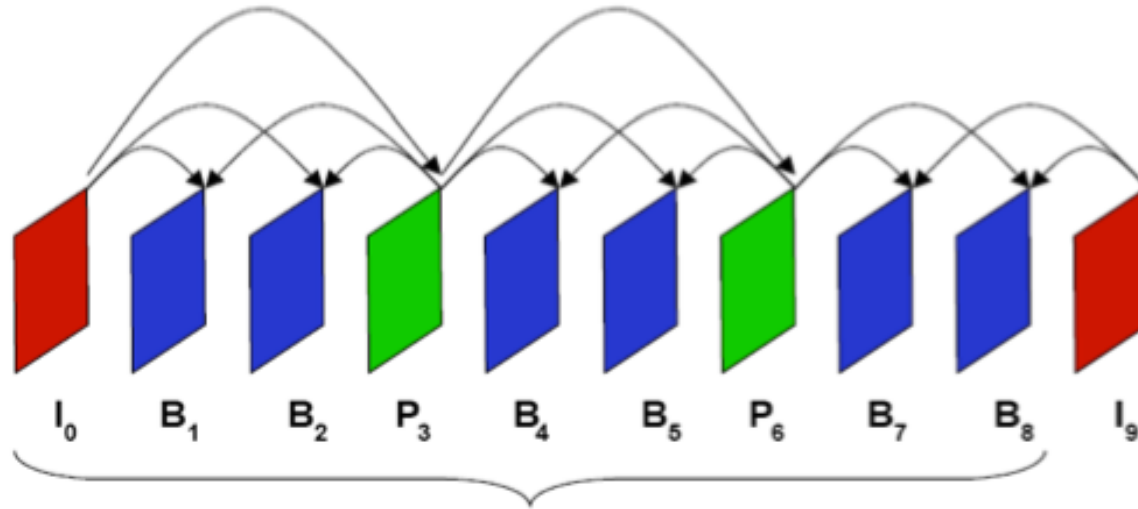


B-frame



Video Compression

Three types of coded frames



MPEG GOP

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

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