Chapter Ten

Basics Video Compression techniques

Why Compress?

Typical 100 minute movie ≈ 150 GB.

• 100 minutes * 60 sec/min * 30 frames/sec * 640 rows * 480 columns * 24 bits/pixel ≈ 1200 Gbits ≈ 150GB

• DVD can hold only 4.7 GB (we need around 32 DVDs to store 100 minute video if not compressed)

You can see compression is a must!

Introduction to video compression

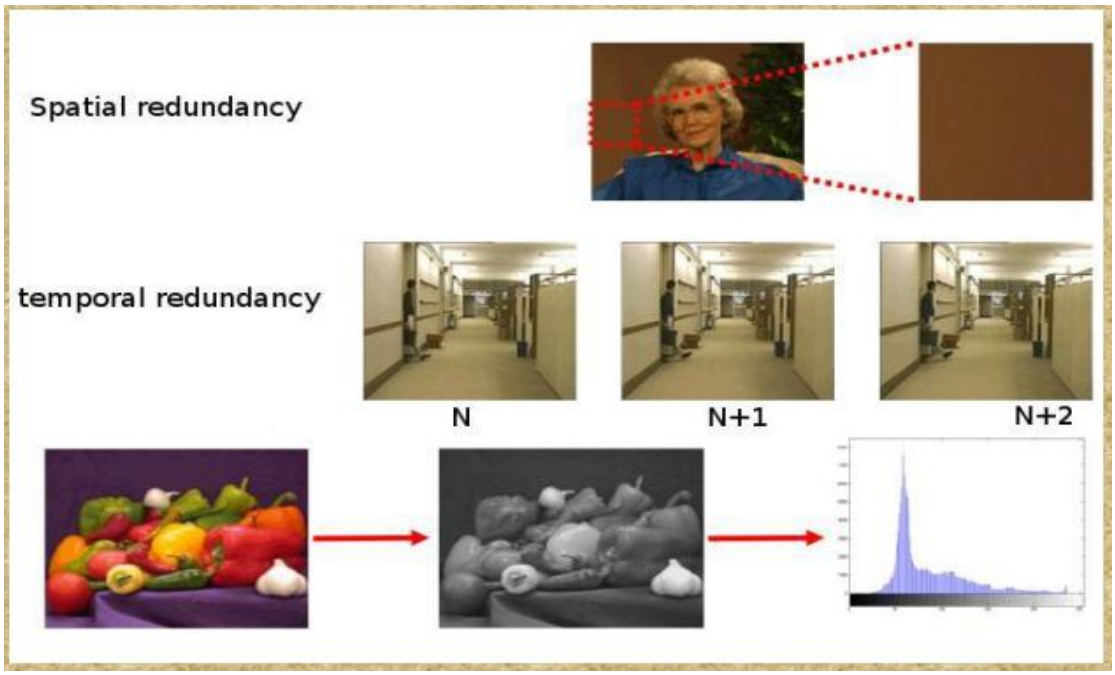
Video is a collection of images taken closely together in time. Therefore, in most cases, the difference between adjacent images is not large. Video compression techniques take advantage of the repetition of portions of the picture from one image to another by concentrating on the changes between neighboring images.

In other words, there is a lot of redundancy in video frames. There are two types of redundancy:

• Spatial redundancy: pixel-to-pixel or spectral correlation within the same frame

• Temporal redundancy: similarity between two or more different frames •

Statistical: non-uniform distribution of data



Video compression based on motion compensation

the MPEG video compression algorithm relies on two basic techniques:

✭ motion compensation for the reduction of the temporal redundancy and transform domain-(DCT)based compression for the reduction of spatial redundancy.

Motion-compensated techniques the techniques that exploit the temporal redundancy of video signals. The concept of motion compensation is based on the estimation of motion between video frames, i.e. if all elements in a video scene are approximately spatially displaced, the motion between frames can be described by a limited number of motion parameters (by motion vectors for translatory motion of pixels). The remaining signal (prediction error) is further compressed with spatial redundancy reduction (DCT). The information relative to motion is based on 16 X 16 blocks and is transmitted together with the spatial information. The motion information is compressed using variable-length codes to achieve maximum efficiency.

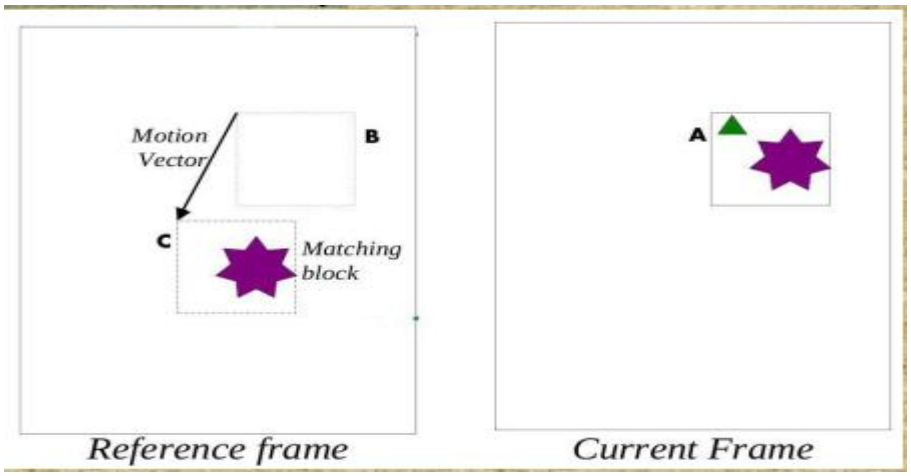


Fig motion compensation

Because of the importance of random access for stored video and the significant bit-rate reduction afforded by motion-compensated interpolation, four types of frames are defined in MPEG:

• Intraframes(I-frames),
• Predicted frames(P-frames),
• Interpolated frames (B-frmes) and • DC-Frames(D-frames)

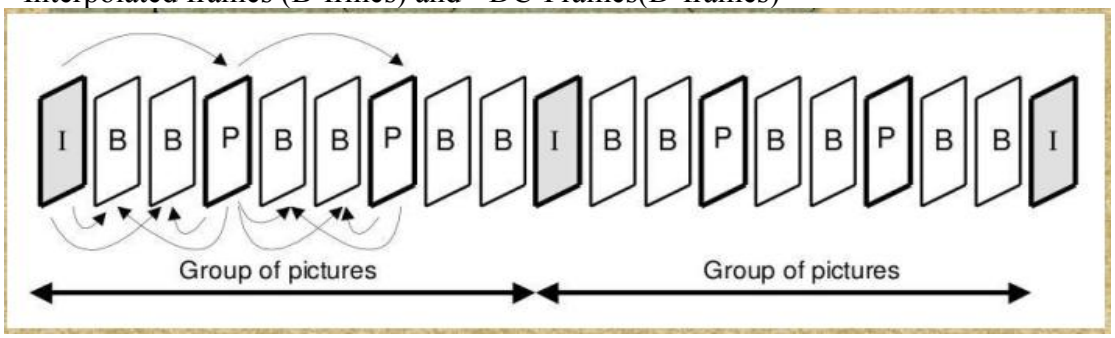


Fig types of frames in MPEG

I-**Frames**

I-frames (Intra-coded frames) are coded independently with no reference to other frames. I-frames provide random access points in the compressed video data, since the I-frames can be decoded independently without referencing to other frames.

With I-frames, an MPEG bit-stream is more editable. Also, error propagation due to transmission errors in previous frames will be terminated by an I-frame since the I-frame does not have a reference to the previous frames. Since I-frames use only transform coding without motion compensated predictive coding, it provides only moderate compression.

P-Frames

P-frames (Predictive-coded frames) are coded using the forward motion-compensated prediction from the preceding I- or P-frame. P-frames provide more compression than the I-frames by virtue of motion-compensated prediction. They also serve as references for Bframes and future P-frames. Transmission errors in the I-frames and P-frames can propagate to the succeeding frames since the I-frames and P-frames are used to predict the succeeding frames

B-**Frame**

B-frames (Bi-directional-coded frames) allow macroblocks to be coded using bidirectional motion-compensated prediction from both the past and future reference Iframes or P-frames. In the B-frames, each bi-directional motion-compensated macroblock can have two motion vectors: a forward motion vector which references to a best matching block in the previous I-frames or P-frames, and a backward motion vector which references to a best matching block in the next I-frames or P-frames.

The motion compensated prediction can be formed by the average of the two referenced motion compensated blocks. By averaging between the past and the future reference blocks, the effect of noise can be decreased. B-frames provide the best compression compared to I- and P-frames. I- and P-frames are used as reference frames for predicting B-frames. To keep the structure simple and since there is no apparent advantage to use Bframes for predicting other B-frames, the B-frames are not used as reference frames Hence, B-frames do not propagate errors

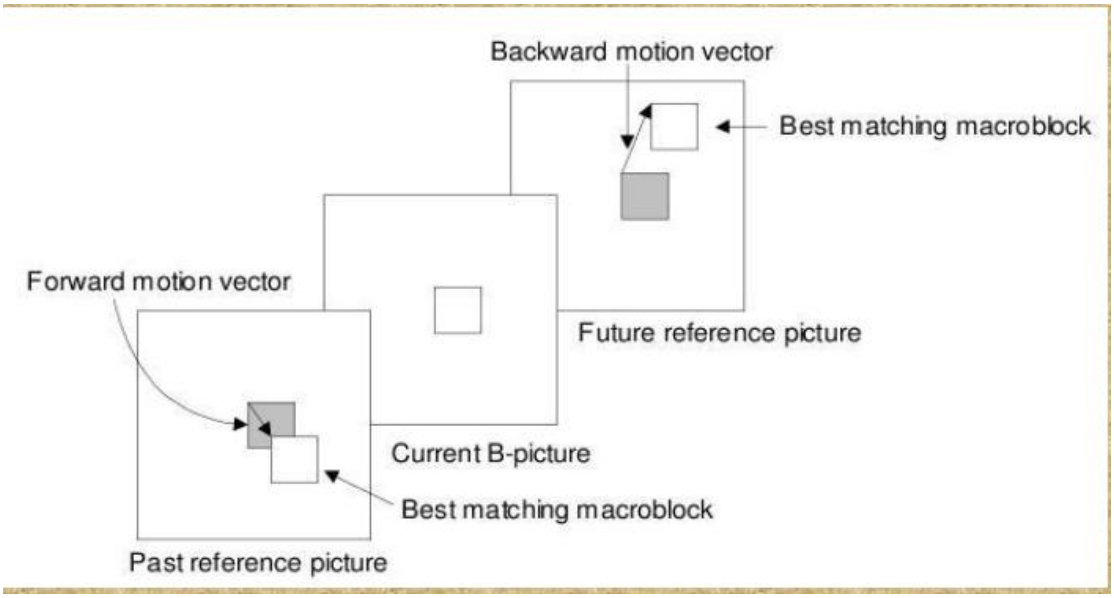


Fig Bi-directional motion estimation

D-Frames

D-frames (DC-frames) are low-resolution frames obtained by decoding only the DC coefficient of the Discrete Cosine Transform coefficients of each macroblock. They are not used in combination with I-, P-, or B-frames. D-frames are rarely used, but are defined to allow fast searches on sequential digital storage media.