Chapter 11.3 MPEG-2

- MPEG-2: For higher quality video at a bit-rate of more than 4 Mbps
- Defined seven profiles aimed at different applications:
  - Simple, Main, SNR scalable, Spatially scalable, High, 4:2:2, Multiview
  - Within each profile, up to four levels are defined
  - The DVD video specification allows only four display resolutions: 720×480, 704×480, 352×480, and 352×240
    - a restricted form of the MPEG-2 Main profile at the Main and Low levels
    - Video peak 9.8 Mbit/s
    - Total peak 10.08 Mbit/s
    - Minimum 300 kbit/s

Level	Simple profile	Main profile	SNR Scalable profile	Spatially Scalable profile	High Profile	4:2:2 Profile	Multiview Profile
High		*			*		
High 1440		*		*	*		
Main	*	*	*		*	*	*
Low		*	*				

Level	Max. Resolution	Max fps	Max pixels/sec	Max coded Data Rate (Mbps)	Application
High	1,920 × 1,152	60	62.7×10^6	80	film production
High 1440	1,440 × 1,152	60	47.0×10^6	60	consumer HDTV
Main	720 × 576	30	10.4×10^6	15	studio TV
Low	352 × 288	30	3.0×10^6	4	consumer tape equiv.

Supporting Interlaced Video

- MPEG-2 must support interlaced video as well since this is one of the options for digital broadcast TV and HDTV
- In interlaced video each frame consists of two fields, referred to as the *top-field* and the *bottom-field*
  - In a *Frame-picture*, all scanlines from both fields are interleaved to form a single frame, then divided into 16×16 macroblocks and coded using MC
  - If each field is treated as a separate picture, then it is called *Field-picture*
  - *MPEG 2* defines **Frame Prediction** and **Field Prediction** as well as five prediction modes

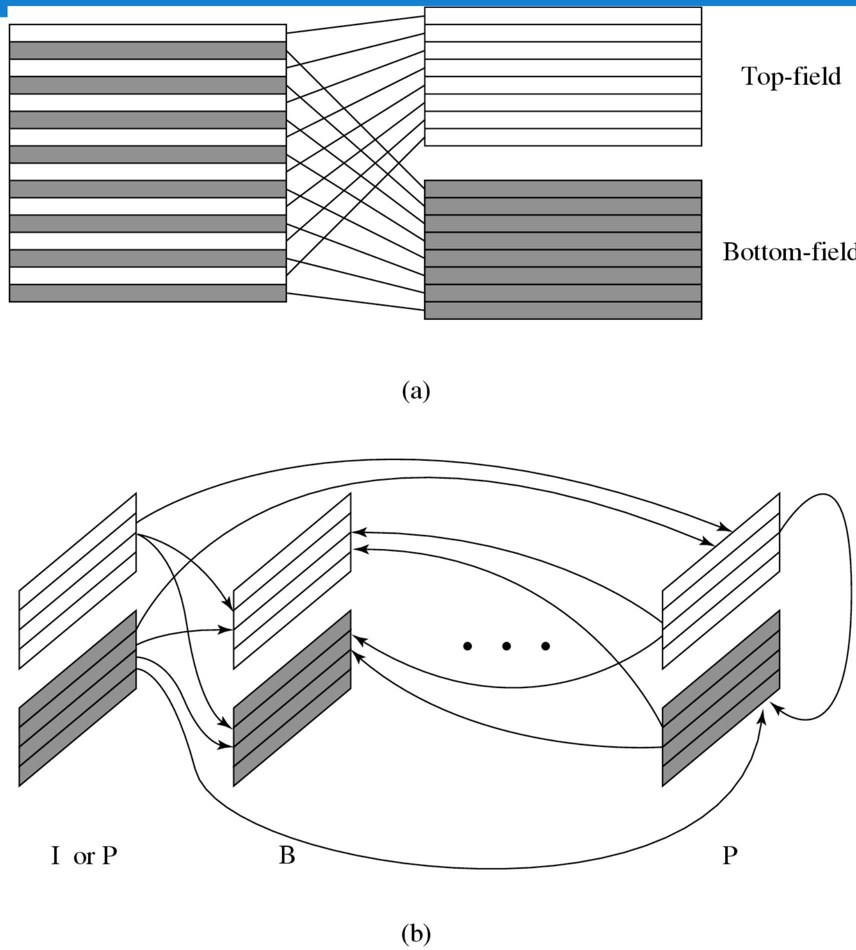
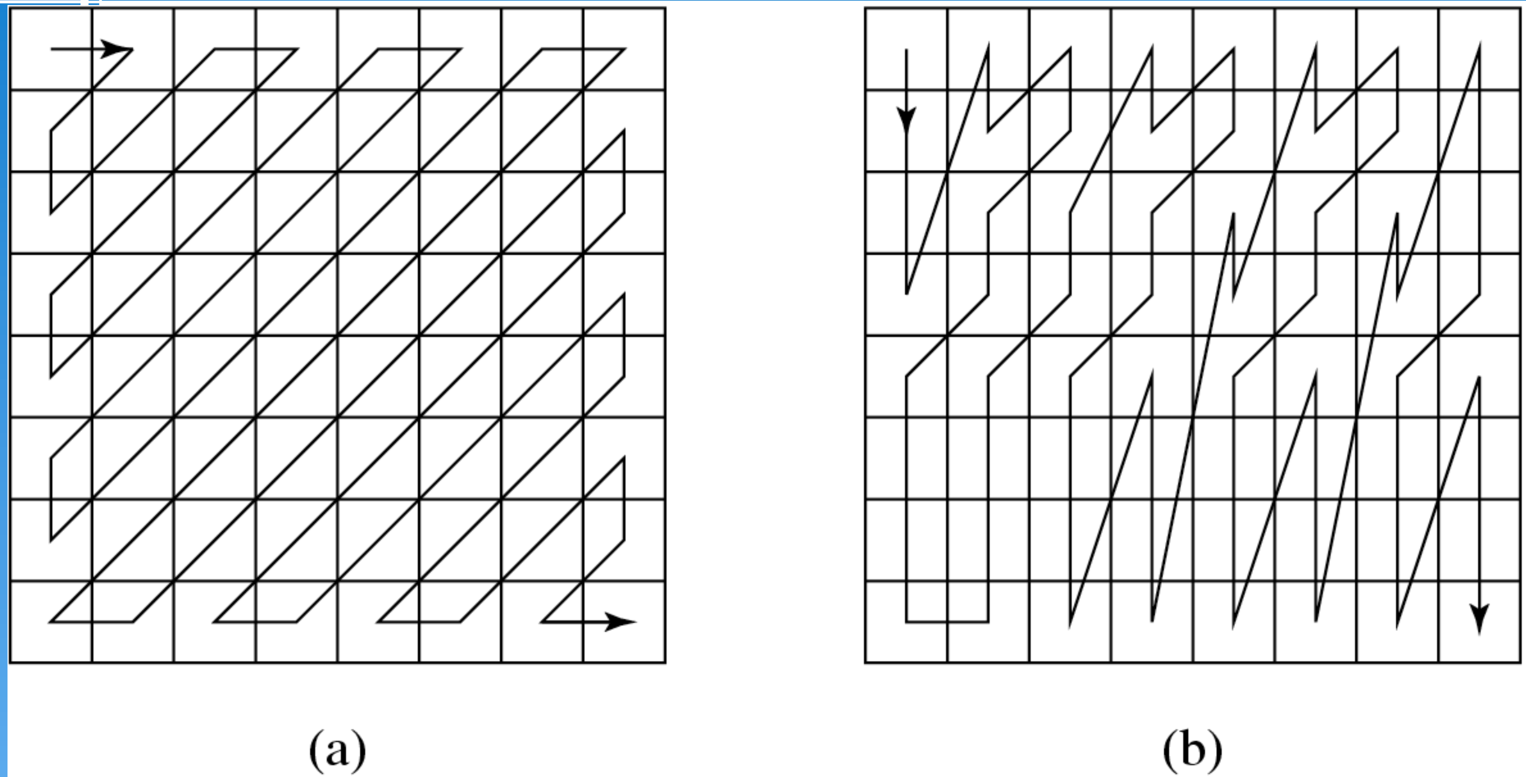


Fig. 11.6: Field pictures and Field-prediction for Field-pictures in MPEG-2.
(a) Frame−picture vs. Field−pictures, (b) Field Prediction for Field−pictures



- Zigzag and Alternate Scans of DCT Coefficients for Progressive and Interlaced Videos in MPEG-2.

MPEG-2 layered coding

- The MPEG-2 scalable coding: A base layer and one or more enhancement layers can be defined
  - The base layer can be independently encoded, transmitted and decoded to obtain basic video quality
  - The encoding and decoding of the enhancement layer is dependent on the base layer or the previous enhancement layer
- Scalable coding is especially useful for MPEG-2 video transmitted over networks with following characteristics:
  - – Networks with very different bit-rates
  - – Networks with variable bit rate (VBR) channels
  - – Networks with noisy connections

MPEG-2 Scalabilities

- MPEG-2 supports the following scalabilities:
  1. SNR Scalability—enhancement layer provides higher SNR
  2. Spatial Scalability — enhancement layer provides higher spatial resolution
  3. Temporal Scalability—enhancement layer facilitates higher frame rate
  4. Hybrid Scalability — combination of any two of the above three scalabilities
  5. Data Partitioning — quantized DCT coefficients are split into partitions

Major Differences from MPEG-1

- Better resilience to bit-errors: In addition to Program Stream, a Transport Stream is added to MPEG-2 bit streams
- Support of 4:2:2 and 4:4:4 chroma subsampling
- More restricted slice structure: MPEG-2 slices must start and end in the same macro block row. In other words, the left edge of a picture always starts a new slice and the longest slice in MPEG-2 can have only one row of macro blocks
- More flexible video formats: It supports various picture resolutions as defined by DVD, ATV and HDTV

Other Major Differences from MPEG-1 (Cont'd)

- **Nonlinear quantization** — two types of scales:
  1. For the first type, scale is the same as in MPEG-1 in which it is an integer in the range of [1, 31] and $scale_i = i$
  2. For the second type, a nonlinear relationship exists, i.e., $scale_i \neq i$. The ith scale value can be looked up from Table

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$scale_i$	1	2	3	4	5	6	7	8	10	12	14	16	18	20	22	24
i	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
$scale_i$	28	32	36	40	44	48	52	56	64	72	80	88	96	104	112	

Chapter 12: MPEG – 4 and beyond

- 12.5: H.264 = MPEG-4 Part 10, or MPEG-4 AVC
  - H.264 offers up to 30-50% better compression than MPEG-2, and up to 30% over H.263+ and MPEG-4 advanced simple profile
- **Core Features**
  - VLC-Based Entropy Decoding: Two entropy methods are used in the variable-length entropy decoder: Unified-VLC (UVLC) and Context Adaptive VLC (CAVLC)
  - Motion Compensation (P-Prediction): Uses a tree-structured motion segmentation down to 4×4 block size (16×16, 16×8, 8×16, 8×8, 8×4, 4×8, 4×4). This allows much more accurate motion compensation of moving objects. Furthermore, motion vectors can be up to half-pixel or quarter-pixel accuracy
  - Intra-Prediction (I-Prediction): H.264 exploits much more spatial prediction than in H.263+

- P and I prediction schemes are accurate. Hence, little spatial correlation let. H.264 therefore uses a simple integer-precision 4 × 4 DCT, and a quantization scheme with nonlinear step-sizes
- In-Loop Deblocking Filters

Baseline Profile Features

- The Baseline profile of H.264 is intended for real-time conversational applications, such as videoconferencing
  - Arbitrary slice order (ASO): decoding order need not be monotonically increasing – allowing for decoding out of order packets
  - Flexible macroblock order (FMO) – can be decoded in any order – lost macroblocks scattered throughout the picture
  - Redundant slices to improve resilience

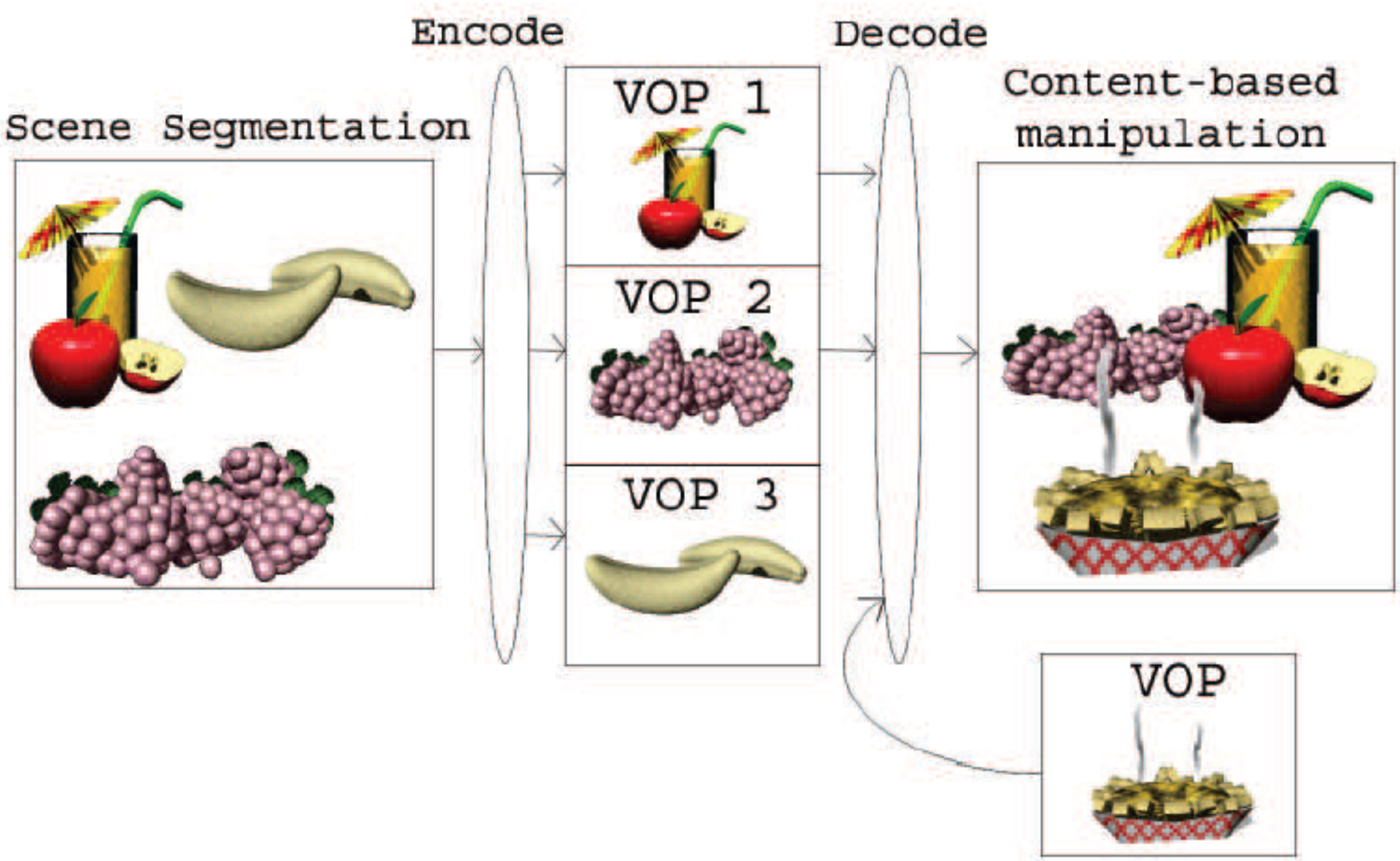
Main Profile Features

- Represents non-low-delay applications such as broadcasting and stored-medium
  - B slices: B frames can be used as reference frames. They can be in any temporal direction (forward-forward, forward-backward, backward-backward)
  - More flexible - 16 reference frames (or 32 reference fields)
  - Context Adaptive Binary Arithmetic Coding (CABAC)
  - Weighted Prediction
- Not all decoders support all the features
  - http://en.wikipedia.org/wiki/H.264/MPEG-4_AVC

MPEG-4

- MPEG-4 adopts a **object-based coding**:
  - Offering higher compression ratio, also beneficial for digital video composition, manipulation, indexing, and retrieval
  - The bit-rate for MPEG-4 video now covers a large range between 5 kbps to 10 Mbps
  - More interactive than MPEG-1 and MPEG-2

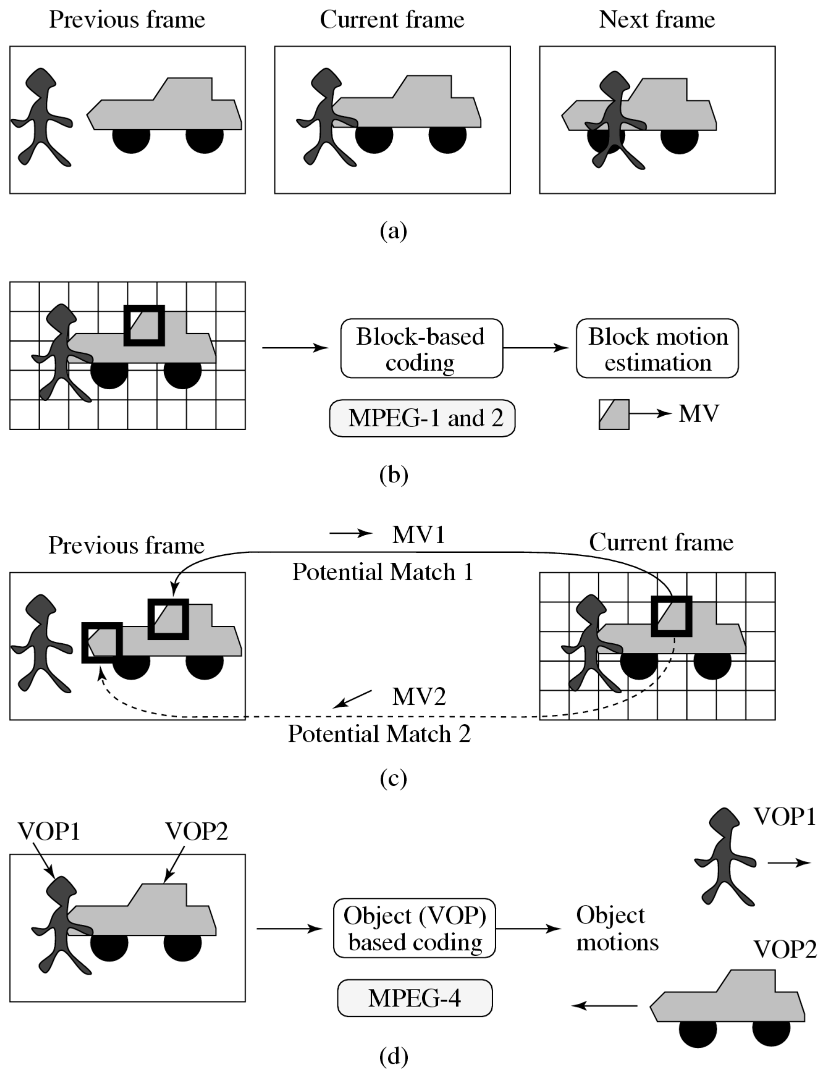
Composition and manipulation of object



Overview of MPEG-4

1. Video-object Sequence (VS)—delivers the complete MPEG-4 visual scene, which may contain 2-D or 3-D natural or synthetic objects
2. Video Object (VO) — a object in the scene, which can be of arbitrary shape corresponding to an object or background of the scene
3. Video Object Layer (VOL) — facilitates a way to support (multi-layered) scalable coding. A VO can have multiple VOLs under scalable coding, or have a single VOL under non-scalable coding
4. Group of Video Object Planes (GOV) — groups Video Object Planes together (optional level)
5. Video Object Plane (VOP) — a snapshot of a VO at a particular moment

Comparison between Block-based Coding and Object-based Coding

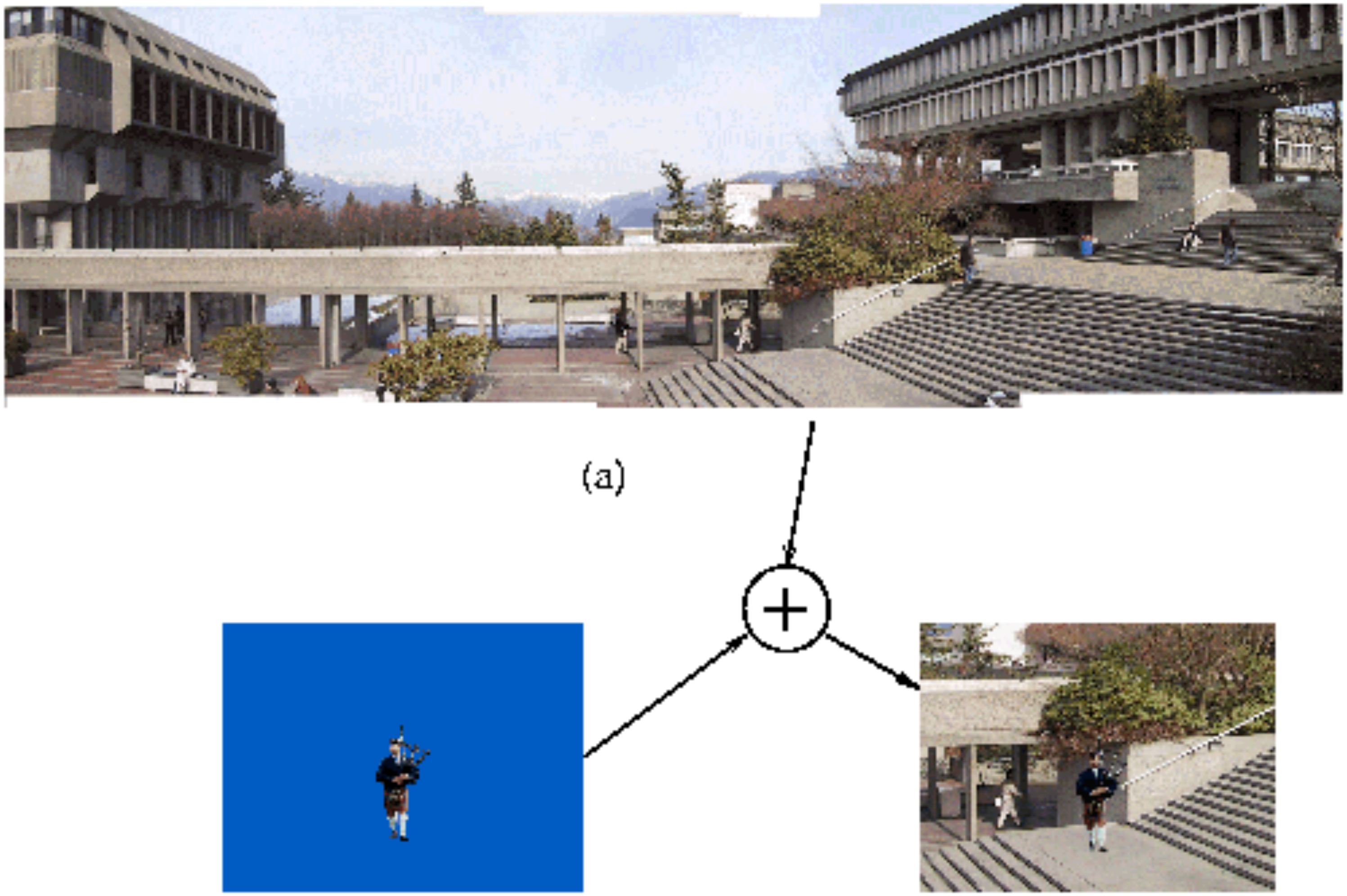


Object oriented

- VOP – I-VOP, B-VOP, P-VOP
- Objects can be arbitrary shape – need to encode the shape and the texture (object)
  - Need to treat MB inside object different than boundary blocks (padding, different DCT etc)

Sprite Coding

- A **sprite** is a graphic image that can freely move around within a larger graphic image or a set of images
- To separate the foreground object from the background, we introduce the notion of a **sprite panorama**: a still image that describes the static background over a sequence of video frames
  - The large sprite panoramic image can be encoded and sent to the decoder only once at the beginning of the video sequence
  - When the decoder receives separately coded foreground objects and parameters describing the camera movements thus far, it can reconstruct the scene in an efficient manner



(a)

(b)

(c)

Global Motion Compensation (GMC)

- “Global” – overall change due to camera motions (pan, tilt, rotation and zoom)
  - Without GMC this will cause a large number of significant motion vectors
- There are four major components within the GMC algorithm:
  - Global motion estimation
  - Warping and blending
  - Motion trajectory coding
  - Choice of LMC (Local Motion Compensation) or GMC.

Profile	Level	Typical picture size	Bit-rate (bits/sec)	Max number of objects
Simple	1	176×144 (QCIF)	64 k	4
	2	352×288 (CIF)	128 k	4
	3	352×288 (CIF)	384 k	4
Core	1	176×144 (QCIF)	384 k	4
	2	352×288 (CIF)	2 M	16
Main	1	352×288 (CIF)	2 M	16
	2	720×576 (CCIR601)	15 M	32
	3	1920×1080 (HDTV)	38.4 M	32