Multimedia Systems

Dr Laura Toni

l.toni@ucl.ac.uk

University College London

Today Lecture

Introduction to Information compression

- Source Coding
- Information and Entropy
- Variable length coding
- Quantization

Multimedia Systems

- Image and Lossy Compression
  - Transforms
  - JPEG Quantization
  - JPEG Lossless Compression

- Video Compression
  - Motion Compensation

Compressing Digital Video

- Exploit *temporal redundancy* between frames
  - Only the sun has changed position between these 2 frames

Previous Frame

Current Frame

- Exploit *spatial redundancy* within frames (like JPEG: transform, quantize, Variable Length Coding)

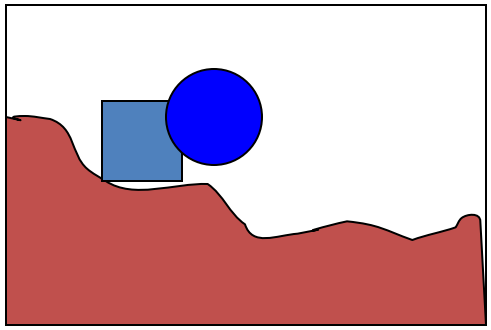
Difference Frames

- Differences between two frames can be caused by
  - Camera motion: the outlines of background or stationary objects can be seen in the Diff Image
  - Object motion: the outlines of moving objects can be seen in the Diff Image
  - Illumination changes (sun rising, headlights, etc.)
  - Noise
  - Scene cuts

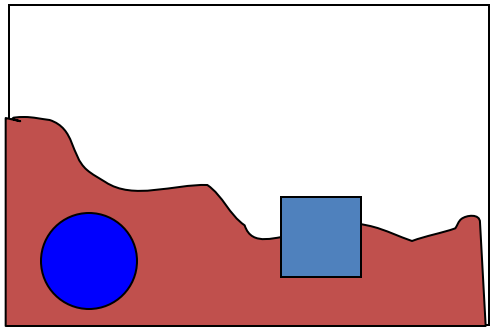
- This difference might still have some correlation – we want to remove it with compression

Types of Motion: Translation

- Translational motion: simple movement of typically rigid objects
- Camera pans vs. movement of objects



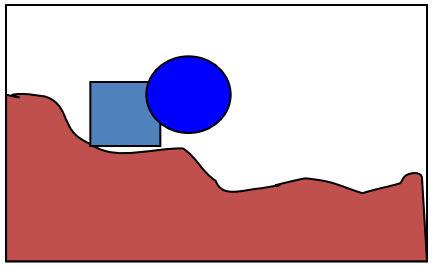
Frame n



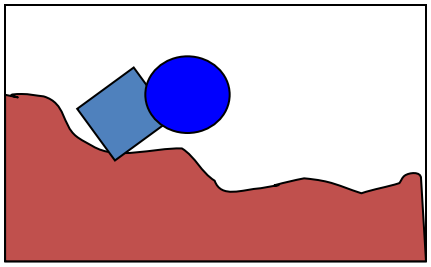
Frame n+1

Types of Motion: Rotation & Zoom

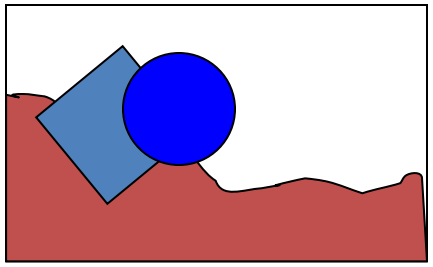
- Rotation: spinning about an axis
  - Camera versus object rotation
- Zooms – zoom in, zoom out
  - Camera zoom vs. object zoom (movement in and out)



Frame n



Frame n+1 (Rotation)



Frame n+2 (Zoom)

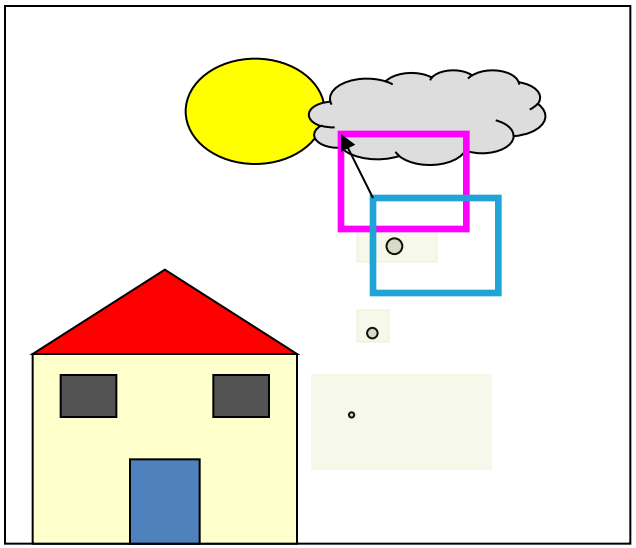
Motion Estimation

- For some portion of the frame, estimate its movement between 2 frames- the *current frame* and the *reference frame*

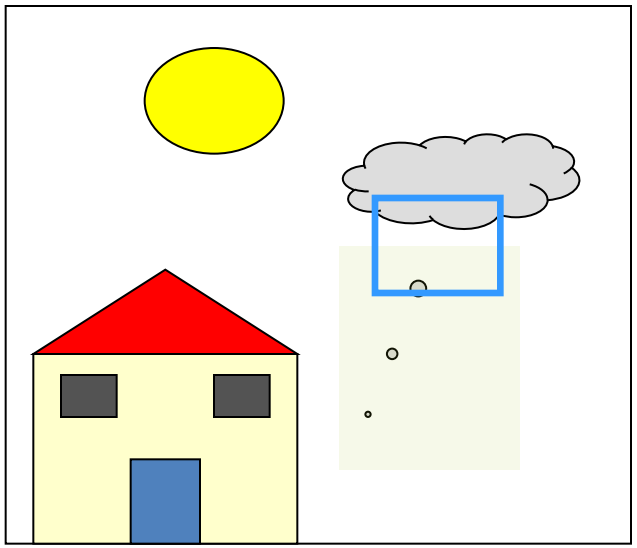
- What is some portion?
  - Individual pixels (all of them)?
  - Lines/edges (have to find them first)
  - Objects (must define them)
  - Uniform regions (just chop up the frame)

Motion Vectors

A *motion vector* (MV) describes the offset between the location of the block being coded (in the current frame) and the location of the best-match block in the reference frame



T=1 (reference)

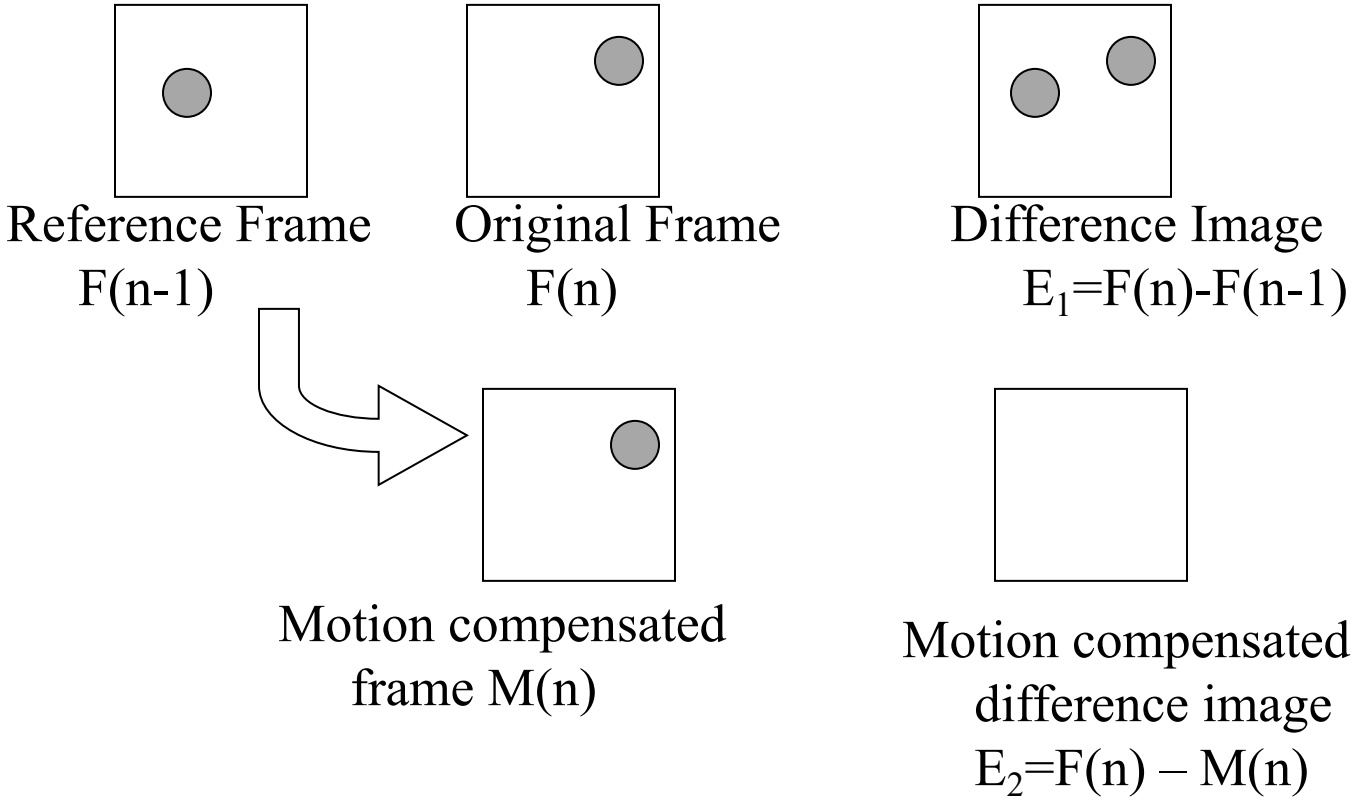


T=2 (current)

Motion Compensation

- This glued together frame is called the *motion compensated frame*
- The encoder can also form the difference between the motion compensated frame and the actual frame.
- This is called the *motion compensated difference frame*
- This difference frame formed using MC should have less correlation between pixels than the difference frame formed without using MC

Motion compensated difference frames

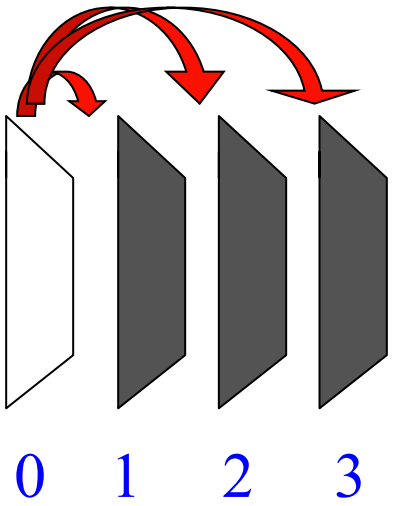


- E_1 & E_2 called prediction error or difference frames
- Do we prefer to compress and send E_1 or MV+E_2 ?

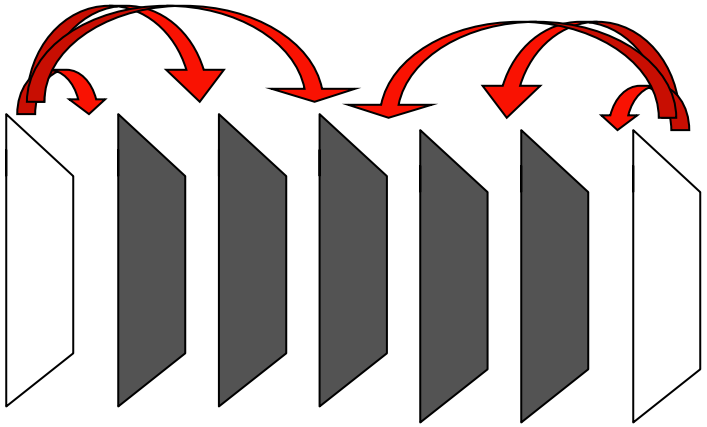
Motion estimation philosophy

- *Most of the time,* for a given representation quality
  - fewer bits to send MV+E_2 instead of sending E_1
  - fewer bits to send E_1 instead of sending F itself.

Reference Frame



Temporal Location of Reference



Thank You

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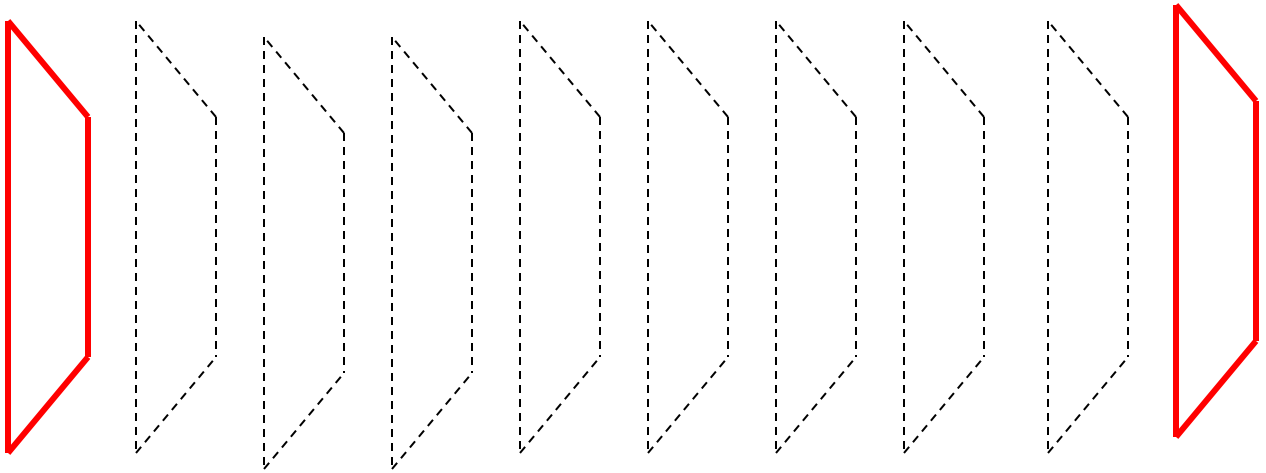
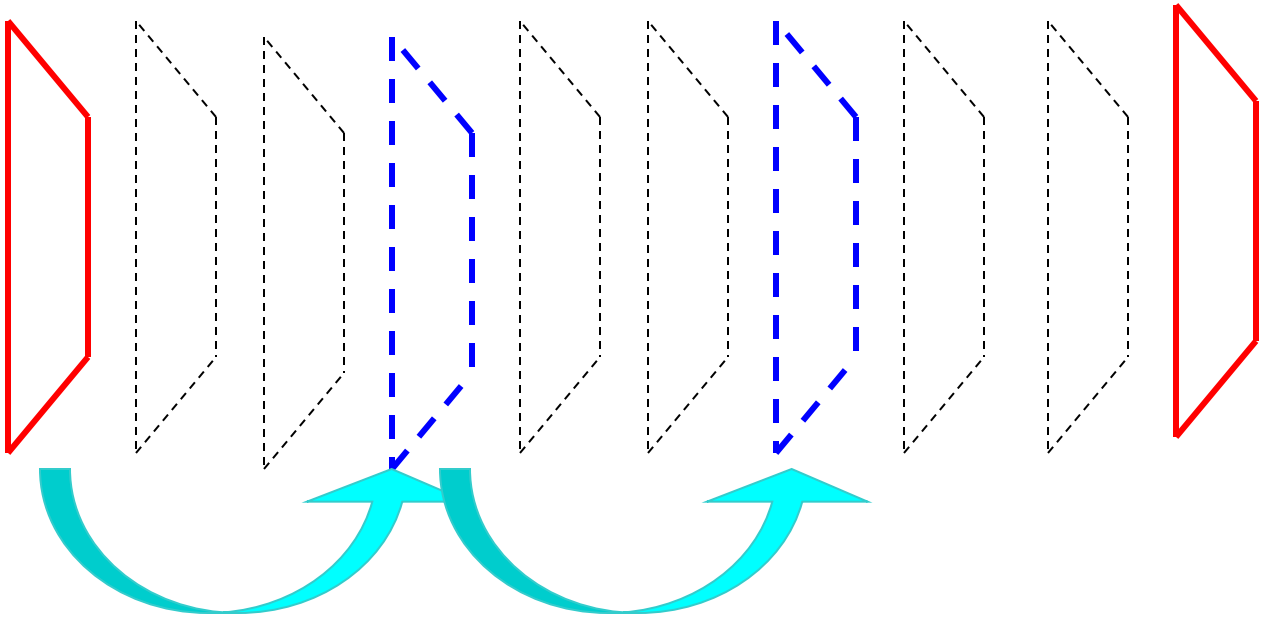
MPEG Frame Types

- Intra (I) pictures: coded by themselves, as still images. No temporal coding. No motion vectors.



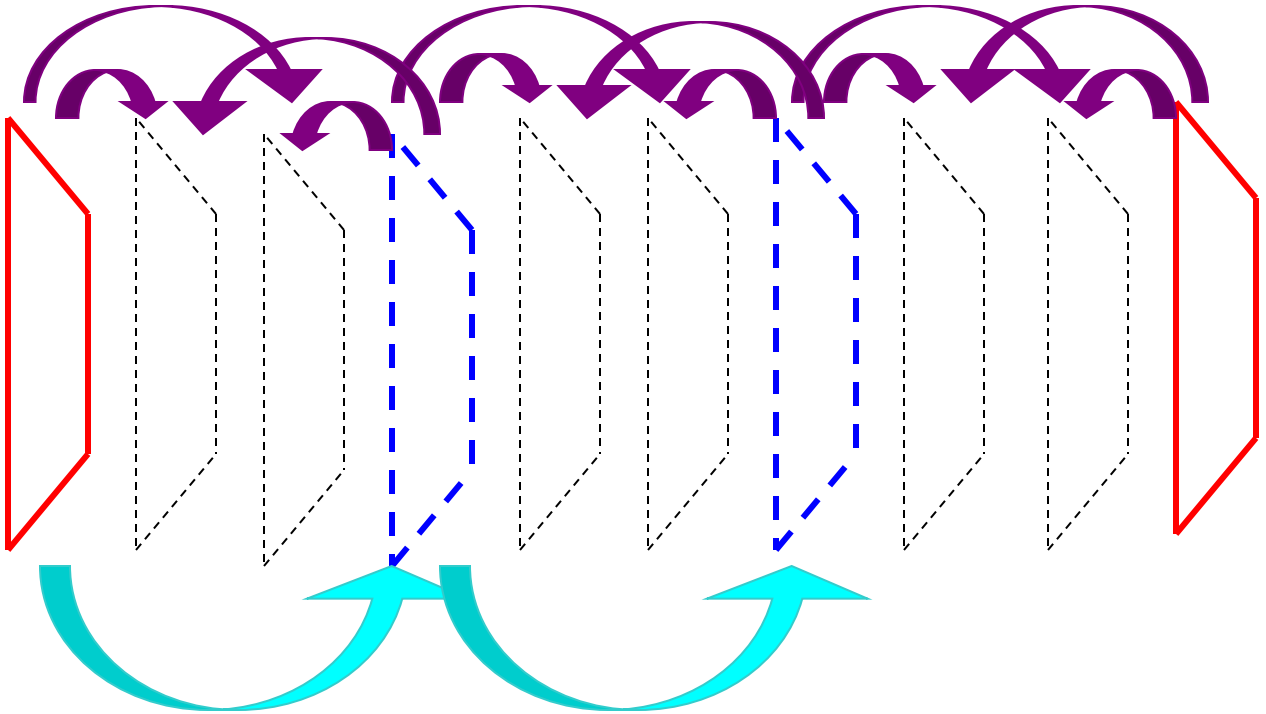
MPEG Frame Types

- Forward Motion Compensated predicted (P) pictures – forward motion compensated from the previous I or P frame

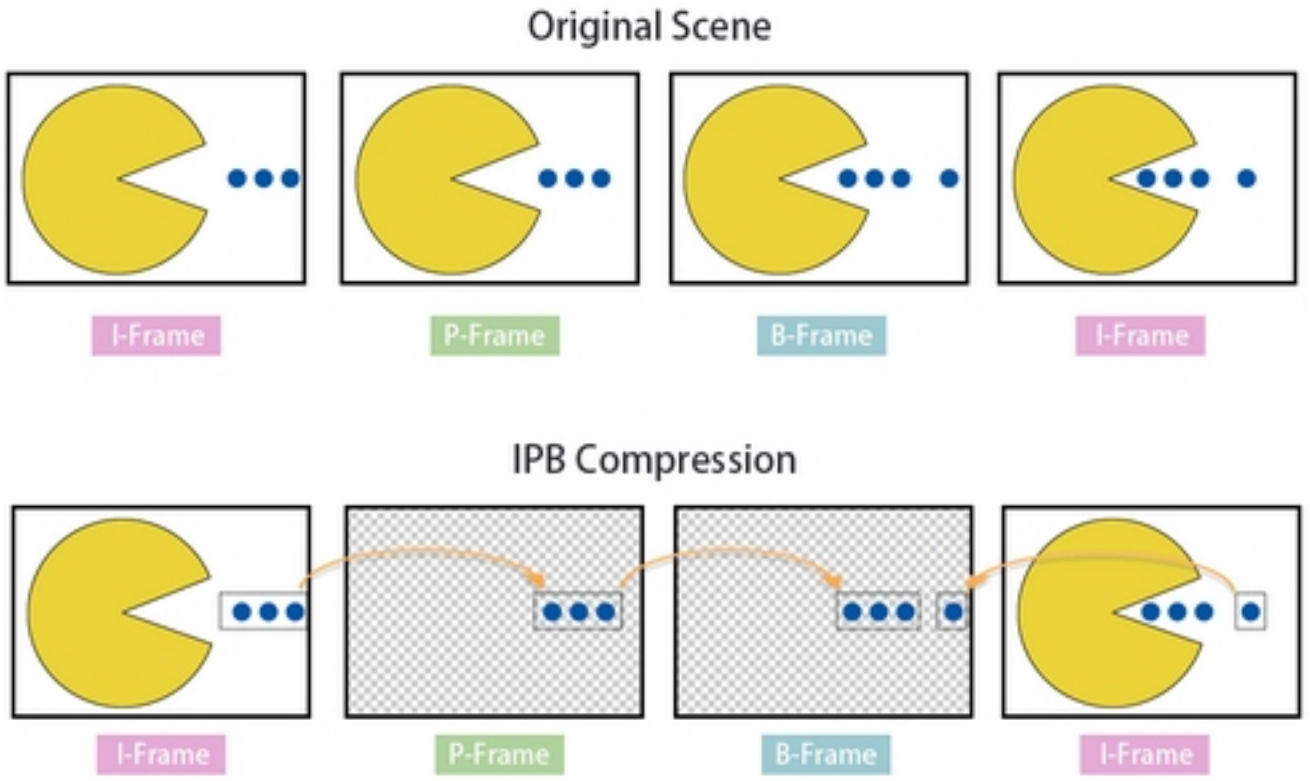


MPEG Frame Types

- Motion Compensated interpolated (B) pictures – forward, backward, and interpolatively motion compensated from previous/next I/P frames

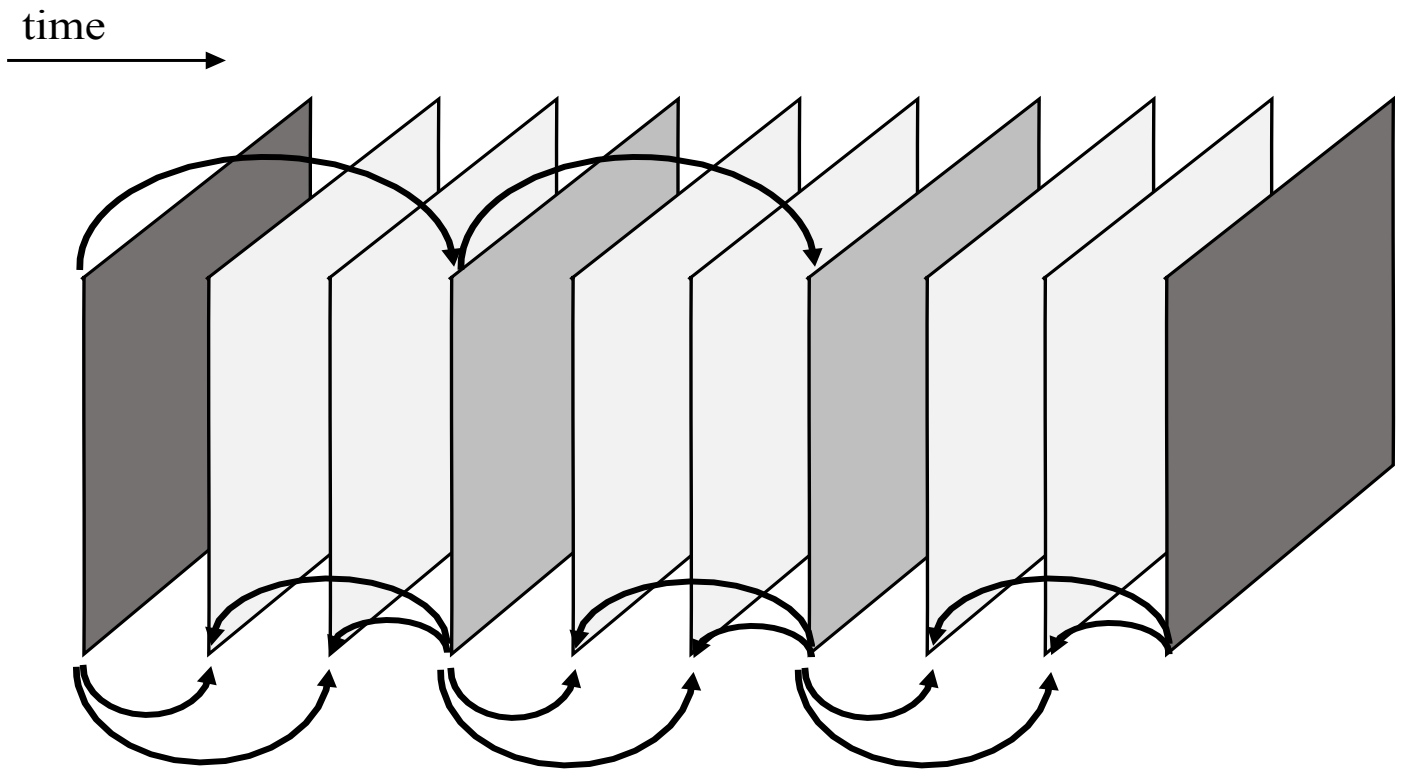


I-P-B Structure - example



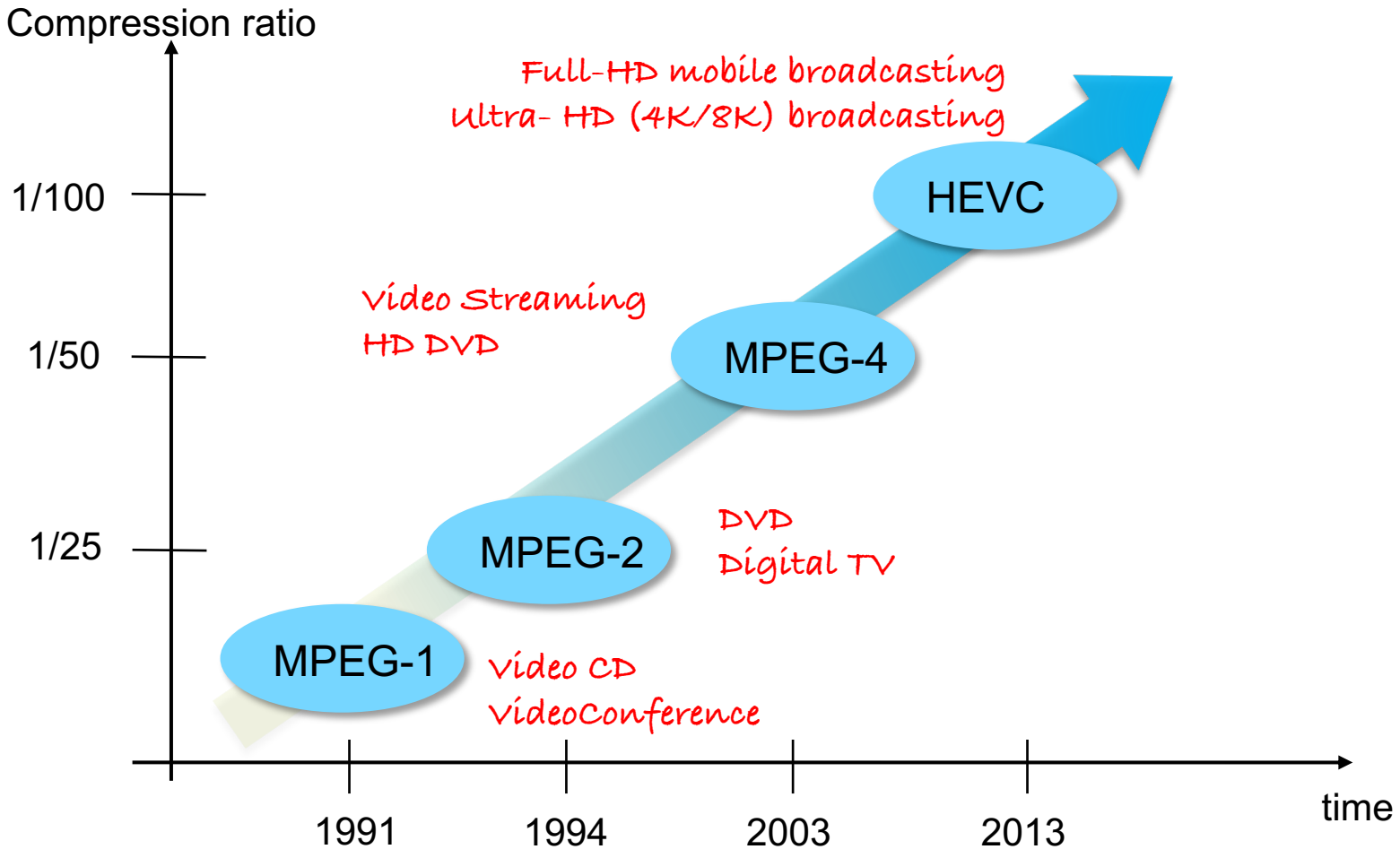
Graphical example that shows how in P and B frames we actually only compress the “difference” with respect to one (or more) reference frame

I-P-B Structure - example



Display order I B B P B B P B B I

History of Video Compression Standards



Competing Codecs

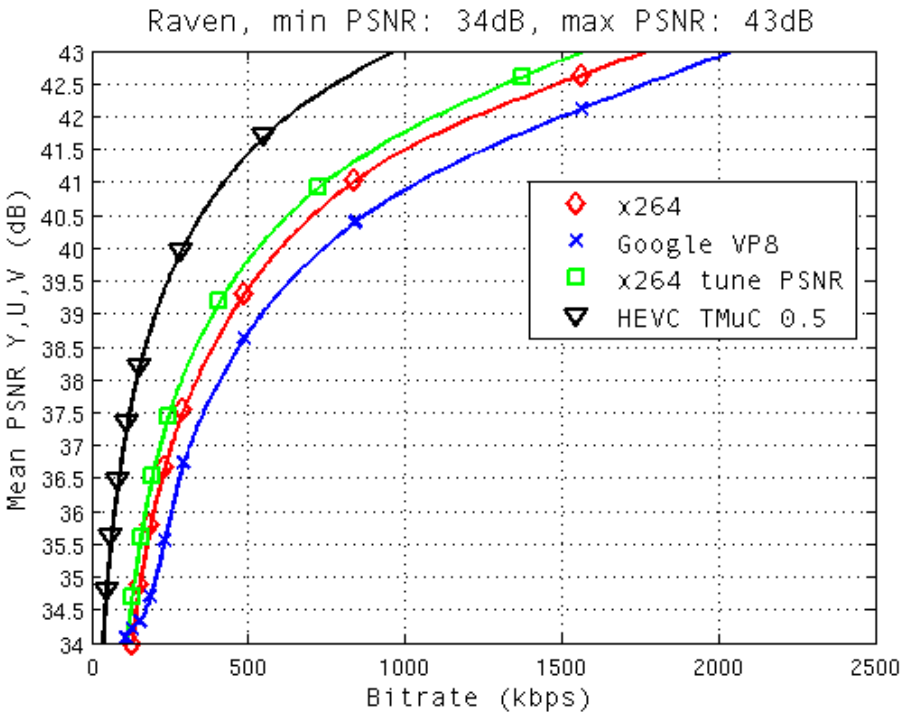
- VP8/VP9,
- AV1
- MPEG/ITU HEVC/H.265

- use scalar or vector quantization
- use temporal compression
- highly asymmetric
- 4K full-HD videos
- Compression up to 50% compared to previous codecs

Competing Codecs

- VP8/VP9,
- AV1
- MPEG/ITU HEVC/H.265

Performance comparison



"Rate-distortion performance of contemporary video codecs: Comparison of Google/WebM VP8, AVC/H. 264, and HEVC TMuC", E Ohwovoriole and Y Andreopoulos - LENS Symp., London, 2010.
http://www.ee.ucl.ac.uk/~iandreop/OHWOVORIOLE_LCS_2010_H264_VP8_HEVC_comparison.pdf

Raw Bandwidth

Raw Bandwidth = color depths * W * L * refresh frequency

Resolution (WxL)	24bit@25fps	8bit@25fps	8bit@15fps	8bit@5fps
4K (3840x2160)	5 Gbit/s	1.6 Gbit/s	995 Mbit/s	331 Mbit/s
HDTV (1920x1080)	1.3 Gbit/s	414 Mbit/s	248 Mbit/s	83 Mbit/s
VGA (640x480)	184 Mbit/s	61 Mbit/s	36 Mbit/s	12 Mbit/s
SCIF (704x576)	240 Mbit/s	80 Mbit/s	48 Mbit/s	16 Mbit/s
CIF (352x288)	60 Mbit/s	60 Mbit/s	12 Mbit/s	4 Mbit/s
QCIF (176x144)	12 Mbit/s	12 Mbit/s	3 Mbit/s	1 Mbit/s

- Uncompressed video is **BIG**
- A DVD would hold max 5 secs of uncompressed video at 1920x1080 resolution
- 6 MHz channel for transmission therefore maximum possible bitrate is 18 Mb/sec
- Requires compression of 83:1

Future Video Applications

Immersive Communications
(holoportation, from Microsoft)

Virtual Reality,
360 Videos

Telepresence
(from Cisco)

Speech/Audio/Video Coding Summary

- Requirements for Coding of each Source
- Speech Coding Principle
- Discontinuous Transmission
- GSM Speech Coding
  - RPE-LPC
  - Enhanced Full Rate
- Different Video Coding Formats, motion compensation

Web References

- 3G Latest

  http://www.umts-forum.org/
- GSM Information

  http://www.gsmworld.com/
- Fraunhofer Full-HD Voice

  http://www.full-hd-voice.com/
- MPEG Information

  http://www.chiariglione.org/mpeg/
- Speech Coding

  http://www-mobile.ecs.soton.ac.uk/speech_codecs/
- Netflix TechBlog

  http://techblog.netflix.com/search/label/encoding