

## C.Sc. 366 Video Compression

Standards...

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### Aims of this lecture...

- Convey the special need for compression when storing and transmitting video
- Cover the key types of video compression
- Appreciate standardisation activities

### Reading...

- "Understanding Networked Multimedia: applications and technology" by Francois Fluckiger, Prentice Hall, 1995. ISBN 0131909924
  - Pages 536-552
- "Digital Multimedia" by Nigel Chapman and Jenny Chapman, Wiley 2000. ISBN 0471983861
  - Pages 300-325
- "Multimedia Systems" by Ralf Steinmetz, Klara Nahrstedt, Prentice Hall, 1995. ISBN 0133244350
  - Pages 146-165

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### Motion Compensation: Summary of terms...

- Interpolation
- Frames:
  - Reference and Intra-coded (I)
  - Predicted (P) and Bidirectional (B)
- Matching Block (& Best Matching Block & error term)
- Macroblock
- Motion Vector
- GOPs
- Display Order and Bitstream (Transmission) Order

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### Lecture Overview...

- Why we need standards...
- ITU Standards
  - H.261
  - H.263
- ISO MPEG standards
  - MPEG-1
  - MPEG-2
  - MPEG-4

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### Standards...

- Standards take time to develop...
- To late technology moves on
- To early no market
- Just right can create a market...

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### ITU Standards...

- ITU
  - International Telecommunication Union
  - H.320 family of standards
    - For teleconferencing
    - Bit Rates 56 to 1930 Kbps
  - Specifically interested in...
    - H.261
    - H.263

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### H.261...

### ITU Recommendation H.261

- Application Domains
  - Video telephony and videoconferencing services over ISDN
- Also referred to as p\*64 (p\*64 Kbit/s channels)
  - Where p=1...30 i.e. 64Kb/s-1.92Mb/s
- Real Time compression/decompression in h/w
- Precise definition of image format provided
  - CIF or QCIF

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## Studio Quality Format...

- Studio Quality for Digital TV
  - NTSC
    - 525 lines and 858 samples per line (Y)
    - 30 Hz
  - PAL
    - 625 lines and 864 samples per line (Y)
    - 25 Hz
  - 4:2:2 Subsampling
    - half number of samples per line for Y than for colour difference components

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## CIF and QCIF

- CIF (cf videoconferencing)
  - 4:1:1 Subsampling used
    - For colour differences,
      - half number of samples per line
      - Number of lines per frame also halved
  - Y = 352\*288 pixels PAL/SECAM (25 fps)
    - Note for NTSC use Y = 352\*240 pixels (30 fps)
  - $C_r = C_b = 176*144$
- QCIF (cf video telephony)
  - Y = 176\*144 pixels PAL/SECAM (25 fps)
  - $C_r = C_b = 88*72$

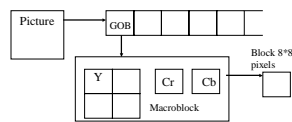
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## GOBs

- H.261 uses only I and P frames
  - IPPPI...
- Macroblocks
  - Comprise six 8\*8 pixel blocks (data units)
    - 4 blocks for Y
    - 1 block  $C_r$ , 1 block for  $C_b$
- Group Of Blocks
  - Matrix of 11\*3 macroblocks
  - 'start code' at the head of each GOB
    - Resynchronisation marker

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## H.261 Data Stream Hierarchy



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## H.261 Formats overview...

- Aspect ratio is 4:3

	CIF	Quarter CIF
Luminance	288 lines by 352 pixels	144 lines 176 pixels
Chrominance	144 lines by 176 pixels	72 lines by 88 pixels
GOB	12	3

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## H.261 Coding Algorithm

- Two types of picture coding
  - Intraframe
    - cf Baseline DCT based JPEG cf MPEG I-pictures
  - Interframe pictures
    - cf MPEG P pictures
- No Bidirectional frames !!

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## H.263...

## H.263

- Application Domains
  - Video telephony, videoconferencing security surveillance etc. over PSTN
- Aimed at very low bit rates
  - Less than 64 kbps (modem rates)
  - Typically operates at 28.8 kbps to 56 kbps.
- Based on H.261 standard
  - ... below 64 kbps H.261 becomes 'blocky'
  - Uses techniques to achieve better compression...

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## H.263

- Uses I, P and B frames
- Enables neighbouring P and B frames to be encoded as a single entity
  - PB-frame
- QCIF at frame rates as low as 3.4 fps
- Sub-QCIF (S-QCIF)
  - Y = 128 x 96,  $C_r = C_b = 64 \times 68$

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## MPEG standards...

## MPEG standards...

- ISO
  - International Standards Organisation
  - Motion Pictures Expert Group
  - Approached specification in 3 phases
    - MPEG-1
    - MPEG-2
    - MPEG-4
- Each standard composed of 3 parts:
  - MPEG-Audio
  - MPEG-Video
  - MPEG-System
    - How audio and video bitstreams should be multiplexed
    - Achieving synchronisation between the two streams

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## MPEG-1...

## Intro to MPEG-1

- MPEG-1:
  - Intended for CD-ROM assuming transmission rate of 1.5 Mbps (1993/4)
    - Audio channel requires 200-250 Kbps for CD quality
    - Therefore bit rate of video should not exceed 1.2 Mbps
  - Targets VCR quality
  - Defines a data-stream syntax and a decompressor
  - Manufacturers are free to develop different compressors
    - Utilises motion compression with spatial compression
    - Similar approach to JPEG, i.e. quantization and coding of frequency coefficients
  - Computationally expensive...

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## MPEG-1: Image Format

- Input format more flexible than H.261
- Optimised for Standard Interchange Format (SIF)
  - 352\*240 pixels NTSC (30 fps)
  - 352\*288 pixels PAL/SECAM (25 fps)
    - Note same resulting bit rate per second
  - Max frame size 4095\*4095 pixels
    - Finite set of frame rates (8)
- Storage:
  - 650 Mbyte CD-ROM can store 40 mins video at 320x240 at 24 fps.

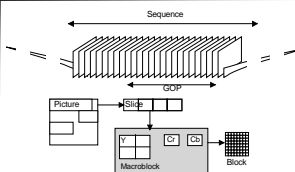
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## MPEG-1 Video Coding

- Video Model Follows Lossy JPEG
  - 4:1:1 subsampling
  - Utilises I, B and P frames
  - Exploits self similarity between successive images
  - *Motion Compensation*

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## MPEG-1 Video Hierarchy



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## Video sequence...

- Commences with a sequence header
- Followed by n GOPs where  $n > 0$
- Ends with a sequence\_end\_code
- GOP
  - Each GOP must contain at least 1 I-frame
  - Assist random access into the sequence
    - Therefore greater apps need for RA the shorter should be the size of GOP

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## Comparison of H.261 and MPEG-1

- Both have precise image format
  - SIF, CIF & QCIF
    - 4:1:1 subsampling ratio
- Compression
  - Both uses DPCM technique based on macroblocks
    - 4 8x8 pixel blocks of luminance
    - 2 8x8 pixel blocks of colour difference
  - But, H.261 has notion of GOB and does not define the use of bidirectional frames.

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## MPEG 2...

## MPEG-2 Intro...

- Motivation...
  - Provide different qualities of image for range of different app domains (with differing target bit rates)
    - e.g. Studio-quality motion video
  - MPEG-2 took on the mantle of MPEG-3
    - Encoding and compression of HDTV

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## Profiles and Levels...

- MPEG-2 supports greater choice of bit rate
  - up to HDTV picture size and resolution
- Allows greater chrominance resolution
  - 4:2:2, 4:4:4
- Support for wider range of apps
  - Family of compression schemes
  - Schemes defined by a profile and a level
    - no single encoder/decoder has to implement functionality
    - Compatibility between newer and older equipment
- 5 Profiles
  - High, Main, Simple, Spatial Resolution etc.

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## Levels...

Level	Frame Size	Target BitRate
High	1920*1152 samples/frame (HDTV)	80/100 Mbps *
High-1440	1440*1152 samples/frame (consumer-HDTV)	60/80 Mbps *
Main	720*576 samples/frame (studio quality TV)	15/20 Mbps *
Low	352*288 samples/frame (VCR) - compatible MPEG-1	4 Mbps

\* Dependent on 4:2:0 or 4:2:2 subsampling

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## MPEG-4...

## MPEG-4 Intro...

- Motivation...
  - Original objective: develop a low bit rate video compression method
  - Now a set of tools for interactive multimedia scene composition, multiplexing and synchronisation
    - Digital television
    - Interactive graphics applications (synthetic content) :
    - Interactive multimedia (World Wide Web, distribution of and access to content)
- 2000 - Achieved 'International Standards Status'

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## Features of MPEG-4

- Coded representation of media objects
- Composition of media objects
- Description and synchronization of streaming data for media objects
- Delivery of streaming data
- Interaction with media objects
- Management and Identification of Intellectual Property

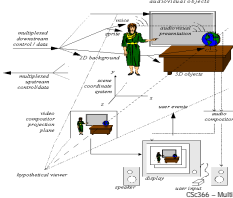
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## Coded representation of media objects...

- Before compression
  - Each scene defined as comprising:
    - A background
    - n audio-visual objects (AVOs)
  - An AVO comprises:
    - n video objects and/or audio objects
  - Video/audio objects
    - Defined as comprising n sub-objects
- Hierarchical structure...

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## Example scene...



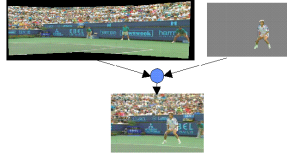
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## Composition of media objects

- standardised way to describe a scene...
  - place media objects anywhere in a given coordinate system
  - apply transforms to change the geometrical or acoustical appearance of a media object
  - group primitive media objects in order to form compound media objects
  - apply streamed data to media objects, in order to modify their attributes
  - change, interactively, the user's viewing and listening points anywhere in the scene.

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## Sprite coding in video sequence



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## Summary...

- ITU
  - H.320 family protocols
    - H.261
      - CIF, QCIF
    - H.263
      - Additionally defines S-QCIF
- ISO MPEG standards for video compression
  - MPEG-1
    - SIF
  - MPEG-2
  - MPEG-4

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