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# Chapter 6 - Video



## Video Multimedia Object

- Combination of image (raster/vector) and audio
- Raw data:
  - enormous data volume:
    - 25 images/s, 250KB/image
    - audio with 11 bit, 16 kHz
    - results in 6250 KB + 22 KB ≈ 6,3 MB per second
  - initially required special storage devices
    - video tape/recorder (VCR), analog picture disc ("laser disc")
- Registration data
  - recording format (VHS, Beta, U-Matic, …) or recorder/player to be used (controlled by computer)
  - time codes
  - file format (MPEG, …)
- Description data
  - structure (scenes):
    - individual scenes/shots (first frame, length)
    - type of shot: panorama, wide shot, figure shot, close-up, pan, zoom

# JPEG

- "Joint Photographic Expert Group"
  - joint activity of ISO/IEC JTC1/SC2/WG10 and Q.16 committee of CCITT SGVIII
  - ISO (international) standard since 1992
- Standard format for raster images
  - support for high compression rates
  - as motion-JPEG used for video, *foundation for MPEG*
- Configuration
  - user can decide about quality of the picture, duration of compression, size of the compressed image
  - compression modes
    - lossy, sequential, DCT-based: baseline mode
    - lossy, extended, DCT-based: set of alternatives to base mode
      - allows progressive mode (image constructed non-sequentially, from blurry to sharp)
    - lossless: low compression rate, no advantage over other formats
    - hierarchical: image stored with different resolutions, each using one of the modes above
- Methods – see literature for details
  - steps: create 8x8 blocks, discrete cosine transformation (DCT), quantization, encoding



# H.261 (p x 64)

- Standard for transmission of moving images over ISDN
  - symmetric method for video phone, video conferencing
  - narrow-band ISDN connection: two B-channels (64 kbit/s each),
- Image/frame size
  - 288 lines of 352 pixels (3:4 ratio) for luminance, 144x176 for chroma (Common Intermediate Format – CIF, for videoconferencing)
    - i.e., only 1 color pixel for 4 brightness pixels
  - support for half resolution (QCIF) for video telephony
  - compression rate 47:1 (for QCIF, 10 fps, 64kbit/s)
- Two steps of compression
  - intra-frame: compresses single-frame data (like JPEG)
  - inter-frame: considers previous frame, identifies similar blocks, stores only difference and motion vectors
  - resulting data stream: compressed images, error correction information, frame numbers (5 bits), command for "freezing" the last displayed frame

# MPEG

- "Moving Picture Expert Group"
  - initially a sub-group of ISO/IEC JTC1/SC2/WG8, now WG11 in SC29
- Video and Audio
  - constant bitrate of up to 1.856.000 bit/s (also suitable for CD-ROM)
  - incorporates JPEG, sequence of still images supported
- Asymmetric compression
  - encoding effort may be way more expensive than decoding
  - max. frame size: 768 x 576 Pixel
- I-frames (intra coded pictures): independent of other frames (like JPEG)
- P-frames (predictive coded pictures): requires previous frame
- B-frames (bi-directionally predictive coded pictures): requires previous and following (I- or P-) frames
- D-frames (DC coded pictures): independent frames, low quality, for fast forward



# MPEG (2)

- Stored image sequence
  - may differ from presentation frame sequence due to B-frames!
- Choosing I-, P-, or B-frames
  - application-dependent
  - heuristic: IBBPBBPBBIBBPBBPBBI ....
  - resulting granularity for random access is 9 frames (330 ms), very good compression rate
- Audio: like Audio-CD or DAT
- MPEG-2:
  - 4–10 Mbit/s,
  - allows for scalability in terms of resolution, bitrates, etc.
  - core standard for DVDs, digital TV

# MPEG-4

- ISO/IEC international standard 14496
  - defines a multimedia system for interoperable communication of complex scenes that may contain audio, video, synthetic/structured audio (MIDI) and graphics
  - started in 1993, Committee Draft in 1997, International Standard in 1999
- Goals
  - for authors: increased flexibility, reuse
  - for providers: generic QoS-descriptors
  - for end users: more interaction
- Provides standardization for
  - encoding of media objects (recorded or synthetic)
  - composition of media objects resulting in scenes
  - multiplexer and synchronizer for transfer
  - interaction

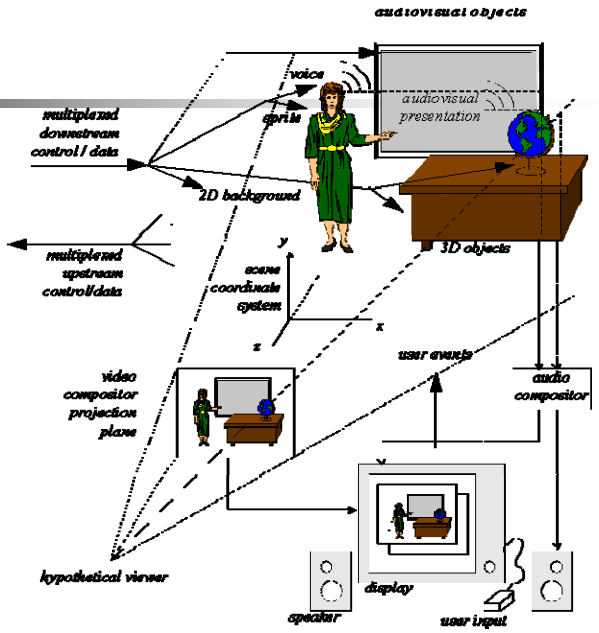


# MPEG-4 (2)

- Parts of the standard
  - systems, video, audio, conformance, reference software, delivery multimedia integration framework (DMIF)
- System
  - framework for the integration of components into scenes
  - hierarchical structure (graph)
  - uses Virtual Reality Modeling Language (VRML)
- Composition
  - frames for audio and video
  - but also **objects**, which make up a scene
    - video objects in different 2D shapes
    - audio objects, possibly associated with video objects
  - description of scenes
    - text, editable or binary (Binary Format for Scene Description, BIFS)

# MPEG-4 (3)

- Composition of a scene
  - arbitrary placement in a coordinate system
  - grouping (e.g., voice/sprite)
  - interactive choice of viewer perspective, position
  - information is preserved in the encoding






# Video Operations

- Play/view
  - on a separate monitor or in a separate window
  - separate process, which needs to allow control bay the user (stop, pause, resume, …)
  - still image (perhaps import into program as a raster image)
  - slow motion, time-lapse
  - possibly other kinds of electronic manipulation (e.g., overlay, bluebox/bluescreen, …)
- Edit, copy, concatenate
  - problems with lossy compression techniques: decompression/re-compression before/after manipulation results in additional loss of quality
- Resynchronization (replace audio track)

# Video Search

- Metadata-based
  - title, author, producer, director, cast/actors, production date, type etc.
- Text-based
  - subtitles, captions
- Audio-based
  - audio track
  - speech or music segment
- Content-based
  - images (frames)
  - all, or in a particular group (scene/shot, see subsequent charts)
- Combination
  - multiple of the above techniques used together
- Goal: Search for complete video and for a part
  - user is only interested in a specific scene of the movie, or a part of the news clip



# Video Query

- Combined approach proposed by [Bolle+1998]
- Stages of video query
  - Navigation: used metadata to direct the search to specific
    - interval of time
    - topic
    - category or genre
    - video server
  - Searching
    - first based on text (filtering)
      - metadata
      - transcribed audio, captions
    - visual aspects (see most of the following discussion)
  - Browsing
    - inspect high-level overviews/summaries
  - Viewing
    - view result object in its entirety
      - play, pause, fast-forward, reverse, …

# Content-based Video Retrieval

- Prerequisite: Segmentation
- Structure
  - Shots
    - filmed with a single camera
    - problem: fading between shots
  - Scenes
    - a series of shots
    - associated with the same situation, part of the film action (i.e., continuous regarding time)
    - e.g., a single dialog
    - harder to identify
    - facilitated (if available) by storyboards, screenplay
- Key frames
  - represent a scene
  - searchable using image retrieval



# Segmentation

- Difference between two consecutive frames
  - quantitative aspect: metric
  - threshold
- Simple metric: sum of pixel differences of two consecutive frames
  - not effective; too many false positives
  - fast motion of big objects result in big differences
- Sum of histogram differences
  - distributions remains similar also with motion

$$SD_i = \sum_j | H_i(j) - H_{i+1}(j) |$$

# Segmentation (2)

- Threshold
  - critical!
  - approach: average distance of consecutive pictures, plus some small tolerance
- Not applicable for gradual shot changes
  - dissolve, wipe, fade-in, fade-out
  - differences are bigger compared to frames within a shot, but smaller compared to "cuts"
- Idea: use two threshold values
  - difference bigger than $T_b$: "cut"
  - difference smaller than $T_b$, but bigger than $T_s$: maybe a gradual change
  - then add all consecutive differences > $T_s$ and compare with $T_b$ again: if bigger, then the frame sequence is a gradual shot change
  - still low recognition rate: < 16%



# Segmentation (3)

- Recognition errors caused by
  - panning and zooming
    - use motion recognition
  - changes in lighting conditions (lamps, clouds, reflections)
    - normalization before computing differences
- Other approaches
  - motion filter before difference computation
  - edge detection
    - count number of edges that (dis-)appear
    - threshold
  - use information automatically recorded by modern cameras
    - position, time, orientation

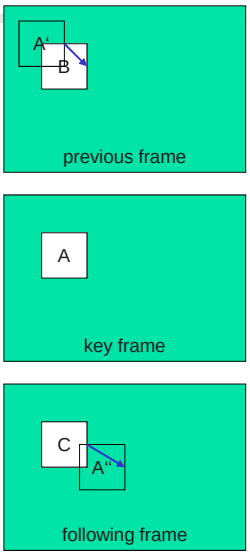
# Key Frames

- Key frames or representative frames (r frames)
- How many per shot?
  - exactly one
  - proportional to the length, e.g., one per second
  - dependent on content (motion, …)
- Which frames?
  - depending on the number of frames; "segment" is either the whole shot, one second, or anything in between
  - "average picture": take every pixel in the pixel-by-pixel intersection of the frames, then determine the most similar frame
  - use histograms instead of pixels
  - separate foreground from background; compile artificial picture



# Motion Information

- Complementing the key frames
- Derive from motion vectors
- Parameter
  - moving content
    - complete motion within shot
  - motion continuity
  - horizontal pan
  - vertical pan
- For complete video, each shot, each key frame



## Scenes

- Time-constrained clustering of shots
  - Determine key frames of all shots
  - Compute similarity "classes" of shots
    - based on the visual characteristics
    - constrained by the temporal location of the shot in the video
      i.e., shots that are similar but far apart don't end up in the same group
- Results in a sequence of "class labels": e.g., A, B, A, C, D, F, C, G, D, F …
  - first scene includes shot 1, the last shot with the same label ("A") and all the intermediate shots
  - for each intermediate shot, the scene has to include the first and last shot with the label as well, …
  - here: scene 1 (A, B, A), scene 2 (C, D, F, C, G, D, F)
- Exploits the fact that there is "discontinuity" between the scenes (e.g., at different locations)



## Scene Types

- Films are made using "a system"
  - film language
  - famous book: Daniel Arijon: Grammar of the film language. Hastings House : New York, 1976
  - e.g., dialog:
    - the person speaking is visible in the shot
    - camera "jumps" to various angles/positions
- Idea:
  - consider the shot labels of each scene
  - pattern: ABABAB …
    - includes timing: interval
  - classify based on production "stereotypes", here: dialog
- More general notion of stereotypes
  - consider lack of repetition, average shot length, …
  - example: fast action scene

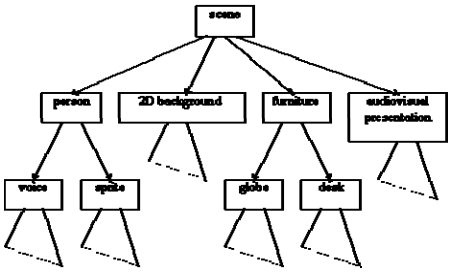
# Visual Summaries for Browsing Results

- Based on techniques discussed above
  - key frames
  - groups/clusters of shots
  - scenes
- Pictorial summary
  - sequence of representative images in temporal order
  - representative image may contain sub-images (e.g., key frames of shot clusters)
- Scene-transition graph (STG)
  - nodes are groups of similar key frames
  - directed edge connects nodes, if one of the shots in the group of the source node directly precedes one of the shots in the group of the target node



# Other Options

- Search over objects
  - MPEG-4
- Search over metadata
- Search over annotations
  - MPEG-7
- Combination of the above



# Summary

- Video multimedia objects
- Formats and encoding
  - JPEG, H.261, MPEG 1, 2, 4
- Video search
  - meta-data, text, audio, visual content
- Content-based video retrieval
  - segmentation
    - shot detection
    - key frames
    - scene detection
    - scene types
  - visual summaries
  - other options