Introduzione alle Biblioteche Digitali Audio/Video

Gestione del video

- **Perchè è importante poter gestire biblioteche digitali di audiovisivi**
- **Caratteristiche specifiche dell'audio/video**
- **Applicazioni delle biblioteche digitali audio/video**
- **Alcuni esempi di biblioteche digitali audio/video**

The importance of video

- **Video can be considered today the primary information and communication channel, due to**
  - Richness in information contained
  - Appeal
- **Video libraries will become essential in many application fields**
  - Personal information
  - Distance learning
  - Telemedicine
  - ……

Video characteristics

- **High video production vs print production**
  - TV stations produce 50 Million hours of video per year (25,000 TB)
  - Newspapers and periodicals produce less than 200 TB of data per year
- **Storage and transmission problems**
  - Video is usually compressed
- **Richness in content**
  - Difficulties in automatic extraction of content description

Services of A/V Digital Libraries

- **Digital Video Libraries are more complex than traditional DLs; they require the integration of several specialized technologies**
- **They offer the same services of text digital libraries**
- **Specific characteristics of Indexing and retrieval services**
  - Indexing based on the integration of different technologies for the automatic feature extraction
  - Integration of manual and automatic indexing
  - Retrieval based on different video features

Characteristics of an Audio/Video DL

The need of A/V DLs

- **Nowadays, video is present in many situations**
  - TV broadcasting
  - Professional applications, such as medicine, journalism, advertising, education, training, surveillance, etc.
  - Movies
  - Historical videos
  - Personal videos
- **The combination of audio and video is a very powerful communication channel**
  - approximately 50% of what is seen and heard simultaneously is retained

Advantages of A/V DLs

- **Most of the video material produced is used only once, due to the difficulty to archive it, to protect and to retrieve.**
- **A large video library of distributed and network searchable videos would enable**
  - Preservation of precious and expensive material
  - Reduction of production costs for new videos, through the reuse of existing material
  - Diffusion of knowledge

In general, it will enable the access to information that could have been lost.

A/V vs traditional DLs [1/2]

- **Library creation**
  - Traditional DLs, contain text documents
    - ➔ **Library creation requires automatic acquisition of text, extraction of document content, and indexing**
    - ➔ **This process is well known and many different techniques have been developed**
  - Video is extremely rich in “content” but ….
    - ➔ **the indexing of video content is difficult, expensive, and extremely dependent from the user and the application**
    - ➔ **A possible approach consists in an appropriate integration of automatic content extraction (e.g. speech recognition, image analysis, etc.) and manual indexing**

A/V vs traditional DLs [2/2]

- **Library exploration**
  - Traditional DLs, contain text documents
    - ➔ **Library exploration requires simple interfaces to formulate queries on free text and document metadata.**
  - Video libraries should permit
    - ➔ **To formulate queries on many different “dimensions”**
      - **Text, as extracted from speech and captions**
      - **Images extracted as key frames**
      - **Motion information**
      - **Other features automatically extracted**
      - **Metadata provided manually**

Applications of Audio/Video DL

Who may use A/V DLs?

- **We consider four main categories**
  - Large companies
    - ➔ **Large corporations that may use Digital Video for their internal business, for advertising, promotion, etc.**
  - Media and entertainment
    - ➔ **The most traditional area. Video is one of the key assets.**
  - Education
    - ➔ **Video recording of courses**
    - ➔ **Video used as course material**
  - Others
    - ➔ **Health and medicine**
    - ➔ **Government**
    - ➔ **Surveillance**
    - ➔ **Etc.**

Large companies

- **Audio/video digital libraries are used for**
  - Sales
  - Product launches
  - Marketing
  - Relation with investors
  - Product design (acquisition and analysis of customer's needs)
  - Support for online sales
  - Video archives for internal use
  - Special services for customers, such as web access to specialized video archives, e.g.
    - ➔ **News**
    - ➔ **Economic information**
    - ➔ **Products**
    - ➔ **Materials**
    - ➔ **Etc.**

Media & Entertainment [1/3]

- **Broadcasting companies**
  - Many broadcasters are creating and distributing video programs on the web. A video archive is very helpful to them to add a new service for accessing old video material.
  - Examples:
    - ➔ **ABC News**
    - ➔ **Mediaset**
    - ➔ **RAI**

- Archive of old programs
- Archive of daily programs
- Additional material w.r.t. tv programs

Media & Entertainment [2/3]

- **Video archives**
  - Many national and private organizations own old video material. The digitalization and archiving of this material is beneficial for content owners (for example, they can promote the use of their material) and for users belonging to different categories: e.g. professional users (that need the material to produce their video programs) or researchers or general public.
  - Examples:
    - ➔ **Istituto Luce**

Media & Entertainment [3/3]

- **Movie production companies**
  - Many large movie production companies own a large amount of video material, composed of the films and of related material, such as cuts not used in the final film version, interview, video trials, etc. This material is very helpful for many purposes, from the production of DVD version of the film up to the critical study of the video. Providing access to the general public of this material is also a powerful promotion and advertising channel.
  - Examples:
    - ➔ **MGM**
    - ➔ **20th Century Fox**

Education

- **Digital video used for different purposes**
  - Promotion and advertising
    - ➔ **Online preview of training content**
  - Store and distribute the video courses
    - ➔ **Remote access of the courses**
    - ➔ **Keep track of classroom discussion**
  - Used as course material
    - ➔ **Delivery of video clips to students, either online or in the classroom**
    - ➔ **From remote sites provide students and teachers with on-demand, searchable access to whole programs and video clips**
    - ➔ **Free search and access to the video library con be used by students to find answers to specific questions, to study in depth some topics, etc.**
  - Production of new courses
    - ➔ **Improve the course production procedures, allowing teachers and producers to remotely access the video library**
  - Examples:
    - ➔ **Princeton University**
    - ➔ **Harward Business School**
    - ➔ **University of Arizona**

Other Applications [1/2]

- **Health and medicine**
  - Health and social care info to the general public
  - Information to physicians for special purpose medical procedures
  - Training

Other Applications [2/2]

- **Government**
  - Enhancement of the governmental decision making process, by recording and archiving of public meetings and discussion.

- **Surveillance**
  - A large amount of video is produced for surveillance purposes.
    - ➔ **Required automatic video analysis**
    - ➔ **Archiving for successive search**

The characteristics of Digital video

Types of data managed

- **A digital video is composed of a sequence of frames plus possibly an audio track.**
- **In general, it is possible to view an audio/video document from different perspectives**
  - The audio part can be separated into
    - ➔ **Speech**
    - ➔ **Sound**
  - Sequence of frames (video shot and sequence)
  - Single frames as images
- **From all of them is possible to extract information that can be used for indexing and retrieval purposes**

Digital video characteristics

- **Sequence of frames with a certain frame rate**
  - NTSC 30 frames/sec, PAL 25 f/s, HDTV 60 f/s
  - Minimal change between frames
- **Single frames resolution**
  - 768 x 576 PAL, 720 x 480 NTSC
- **Uncompressed video requires high storage space and bandwidth**
  - For example, one second of uncompressed PAL video requires

    768 x 576 x 16 x25 ~ 172 MByte

Digital video storage and transmission [1/3]

- **The high storage requirements of video imposes the adoption of compression techniques.**
- **High compression rates are possible with video signals, due to the following reasons:**
  - Spatial correlation: correlation among neighboring pixels
  - Temporal correlation: correlation among pixels in different frames
  - A significant part of video data is not perceived

Digital video storage and transmission [2/3]

- **Compression can be divided in two broad categories**
  - **Lossless compression**, that allows one to compress decompress video without any degradation
    - ➔ **Lossless compression provides low compression factors**
    - ➔ **An example of lossless compression is MJEPG, where each frame is compressed using the JPEG format**
    - ➔ **Examples of lossless coding techniques are run-length coding, Huffman coding**

Digital video storage and transmission [3/3]

- **Lossy compression**, where the complete cycle of compression and decompression introduces some degradation of the original video
  - ➔ **Lossy compression allows to obtain high compression factors**
  - ➔ **Examples are the MPEG compression family (MPEG1, MPEG2)**
  - ➔ **Example of lossy coding is DPCM**
    - – **DPCM compares adjacent pixels and stores only their difference**

MPEG

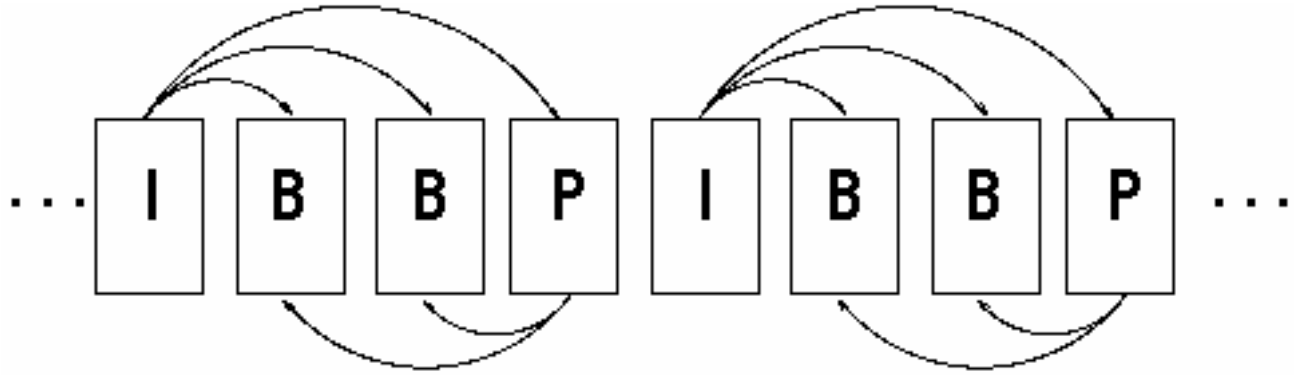
- **MPEG (Moving Pictures Experts Groups)**
  - MPEG1 has a bit-rate up to 1.5Mb/sec
    - ➔ **Designed for storage and retrieval of VHS quality video on CD-ROM**
  - MPEG2 Designed for broadcast video quality
    - ➔ **Bit rate: 2Mbps or higher**
    - ➔ **Used for DVD, cable TV, etc.**
  - MPEG4 is object-based, multi stream
    - ➔ **Variable bit-rates, from <64 kbps, up to 4Mbps and more (in the future)**

MPEG-1 [1/2]

- **Compression based on intra-frame and inter-frame encoding**
- **Intra-frame coding**
  - Each frame is subject to compression
  - Uses DCT compression schema
- **Inter-frame coding**
  - Exploits temporal redundancy
  - Predictive coding
    - ➔ **current picture is modeled as a transformation of picture at some previous time**
  - Interpolative coding
    - ➔ **Uses past and future pictures for reference**

MPEG-1 [2/2]

- **MPEG uses three types of frame coding**
  - I frames: intra-frame coding
    - ➔ **Moderate compression**
    - ➔ **Access points for random access**
  - P frames: predictive-coded frames
    - ➔ **Coded with reference to I or P frames**
  - B frames: bi-directionally predictive coded
    - ➔ **Coded using previous/next I and P frames**
    - ➔ **High compression**



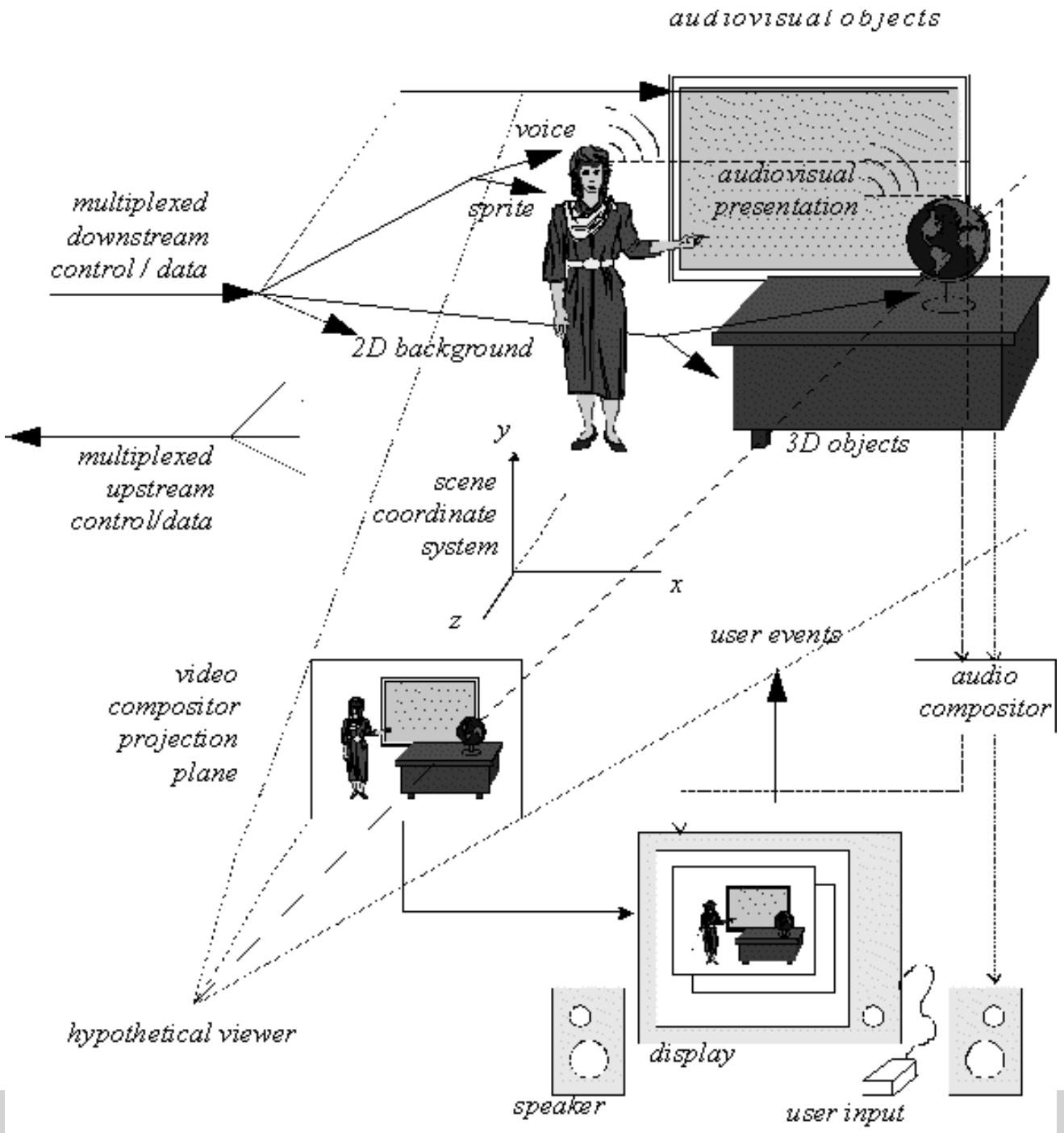
MPEG-4 [1/4]

- **Scalability of bit rate vs quality**
- **Better Audio/Video compression than MPEG-1**
- **Content based coding**
- **Support for efficient streaming**

MPEG-4 [2/4]

- **Content based coding**
  - Reusability of object coding
  - Adaptation (different coding for different objects)
  - High quality for interesting parts
  - Possibility of scene composition
    - ➔**Integration of natural and synthetic content**
    - ➔**Tele-presence**

MPEG-4 [3/4]


audiovisual objects
voice
sprite
multiplexed
downstream
control / data
audiovisual
presentation
2D background
3D objects
multiplexed
upstream
control/data
y
scene
coordinate
system
x
z
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compositor
projection
plane
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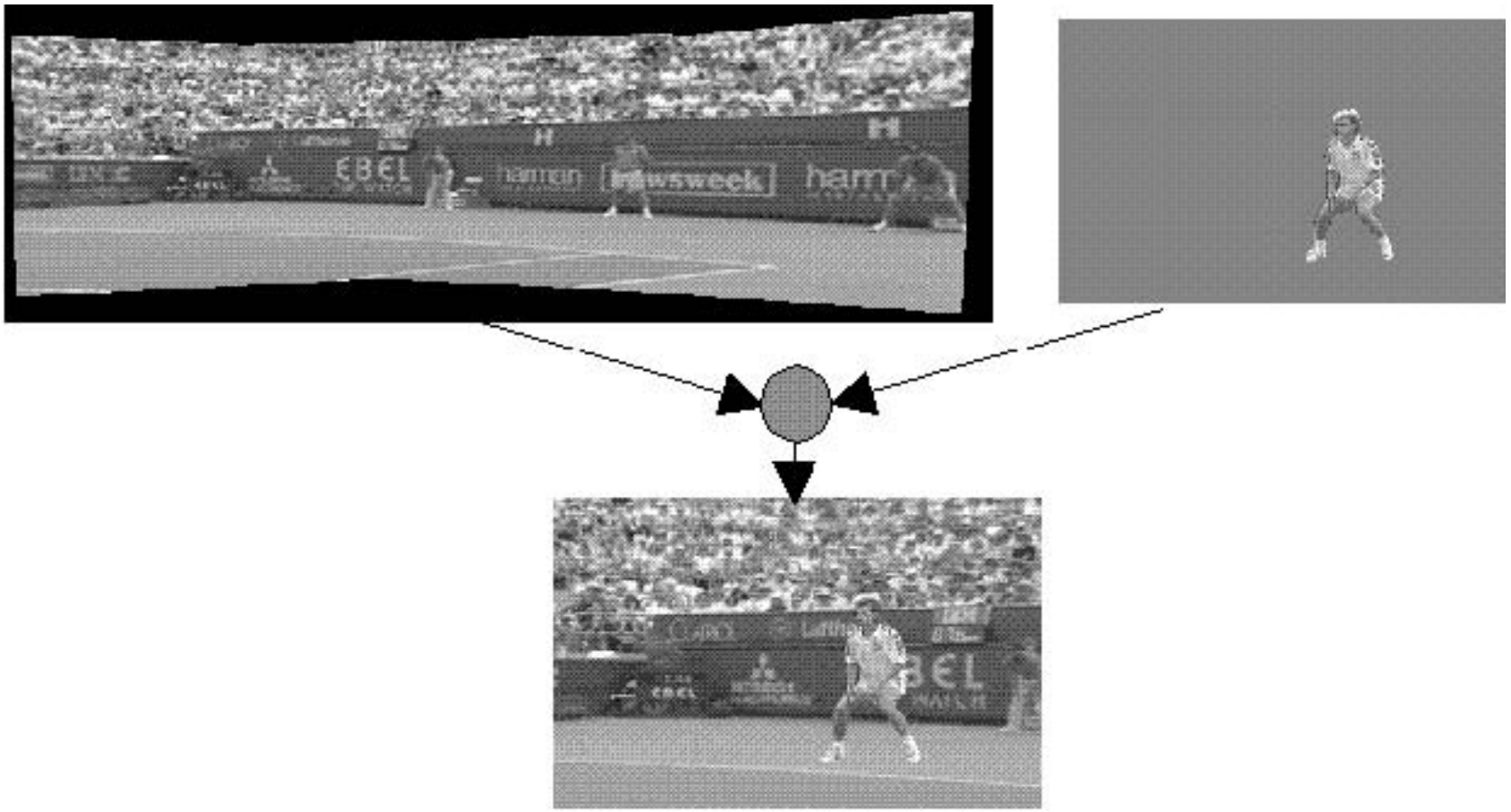
compositor
hypothetical viewer
display
speaker
user input

MPEG-4 [4/4]



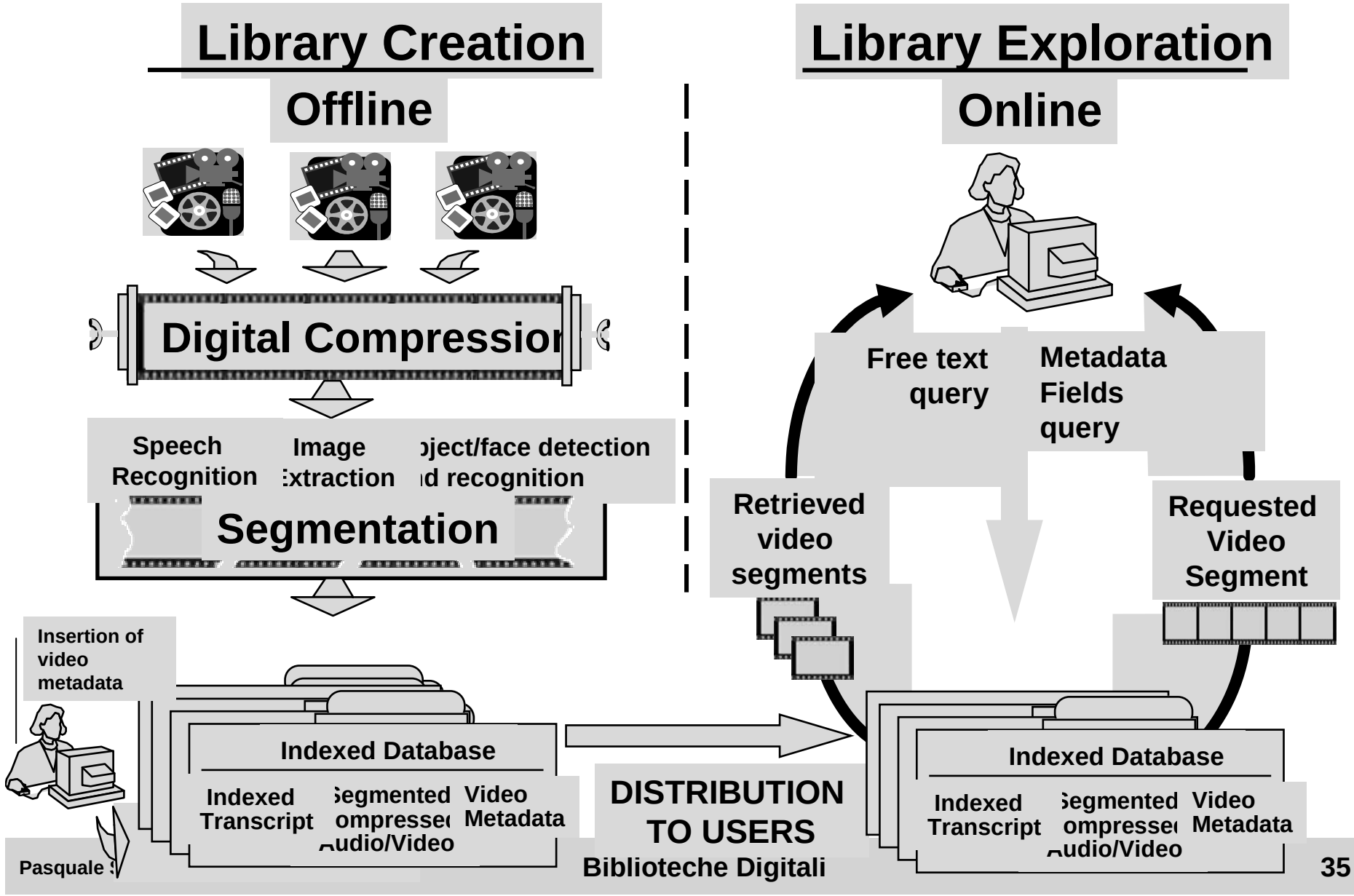
Digital Video representation

- **Video is composed of a sequence of** frames
- **Video is separated into** shots
  - A shot is a sequence of frames separated by a transition
  - Transitions between shots are given by
    - ➔ **Camera break**
    - ➔ **Dissolve**
    - ➔ **Wipe**
    - ➔ **Fade-in, fade-out**
- **A video can be separated into** sequences**, that are semantically meaningful groups of shots, possibly non consecutive**

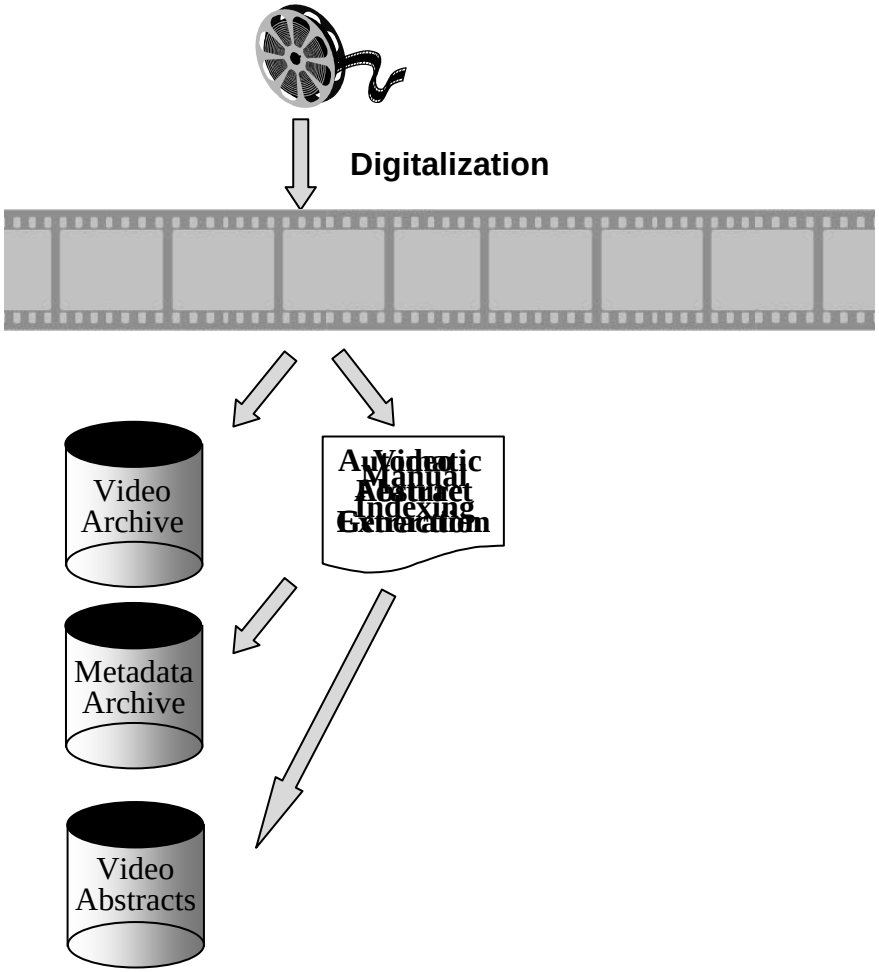
Operations of an A/V Digital Library

- **Video archiving and indexing**
- **Video storage**
- **Content-based search**
- **Video access (visualization and copy)**

Summary of all phases & operations



Data flow of the Digital Library creation



Digital video

Archival of raw video

Archival of automatically extracted features

Archival of metadata inserted manually

Archival of Video Abstracts

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Automatic and manual indexing of Audio/Video documents

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What is the purpose of video indexing

- **The indexing process provides a "description" of video content that can be used to support the retrieval process**
- **Three main categories of video descriptions**
  - Keywords describing the entire video
  - Visual properties
  - Semantic information

Automatic vs manual indexing

- **The goal is to provide a completely automatic indexing**
  - Fast
  - Reliable (user independent, error reduction)
- **In many cases this is not possible**
  - Complexity of the task (e.g. semantic interpretation of a shot content)
  - Information is not available in the video (e.g. creation date, place where the movie was recorded)

Information that cannot be extracted automatically

- **Background information, e.g.**
  - Creation date
  - Author
  - Names of the actors
  - Ecc.

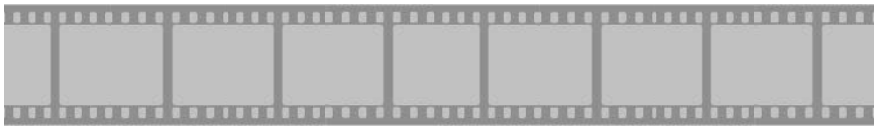
- **Semantic information**
  - Relations among different shots
  - Interpretation of the meaning of a shot
  - Interpretation of the meaning of a frame

- **All this type of information must be provided manually, possibly by using a specific tool**

Information that can be extracted automatically

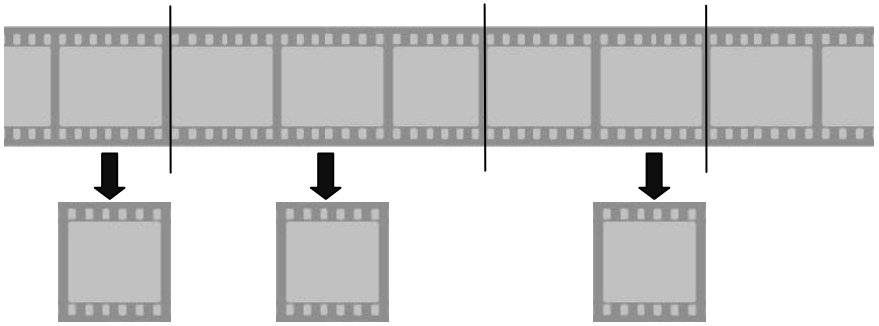
- **Features that can be extracted from the entire video,**
  - e.g. frame rate, resolution, b&w or color video, etc.
- **Features that are associated to the audio part**
  - e.g. the transcript of the speech
- **Features that can be extracted from each shot**
  - e.g. object track, camera movement, recognition of specific objects, recognition of faces, text captions, key frames
- **Features that can be extracted from each frame**
  - these are typical image features, such as color distribution, texture, object's shapes, etc.

Automatic feature extraction



Digital Video

Segmentation



Key frame extraction

Speech extraction and recognition

Object recognition

Face detection and recognition

Video segmentation [1/2]

- **Segmentation is needed in order to identify the index units for video content. These units are *generic clips* which correspond to individual camera shots.**
- **A *generic clip*, which is the basic indexing unit, is defined as a single uninterrupted camera shot.**
- **Video partitioning consists in detecting boundaries between consecutive camera shots.**
- **The type of transitions between shots are**
  - camera break (the simplest to be detected), dissolve, wipe, fade-in, fade-out

Video segmentation [2/2]

- **Detection of camera break**
  - **Pair-wise Pixel comparison** Given two consecutive frames, corresponding pixels are compared and the number of pixels changed is determined. For monochromatic images, a pixel is judged as changed if the difference between its intensity values in the two frames exceeds a given threshold T.
  - **Histogram comparison** This method uses a comparison of some feature of the images. For example it may use the histogram of intensity levels. The principle behind this approach is that two frames having an unchanging background will show little difference in their respective histograms. This method is less sensitive to object motion because it ignores the spatial changes in a frame.
  - **Motion continuity** Motion can be represented quantitatively by assigning a field of motion vectors to the pixels of an image. The motion vectors are computed by dividing each frame into blocks and determining where each block is located in the successive frame. A correlation between the two frames can be computed; a low correlation between two consecutive frames is interpreted as a camera break.

Image indexing

- **Image indexing is performed on key frames**
- **Image indexing is difficult, since the concept of image similarity is not precise**
- **Two different indexing approaches**
  - Based on image visual features
    - ➔ **Color, texture, object's shape, etc**
  - Based on a semantic information

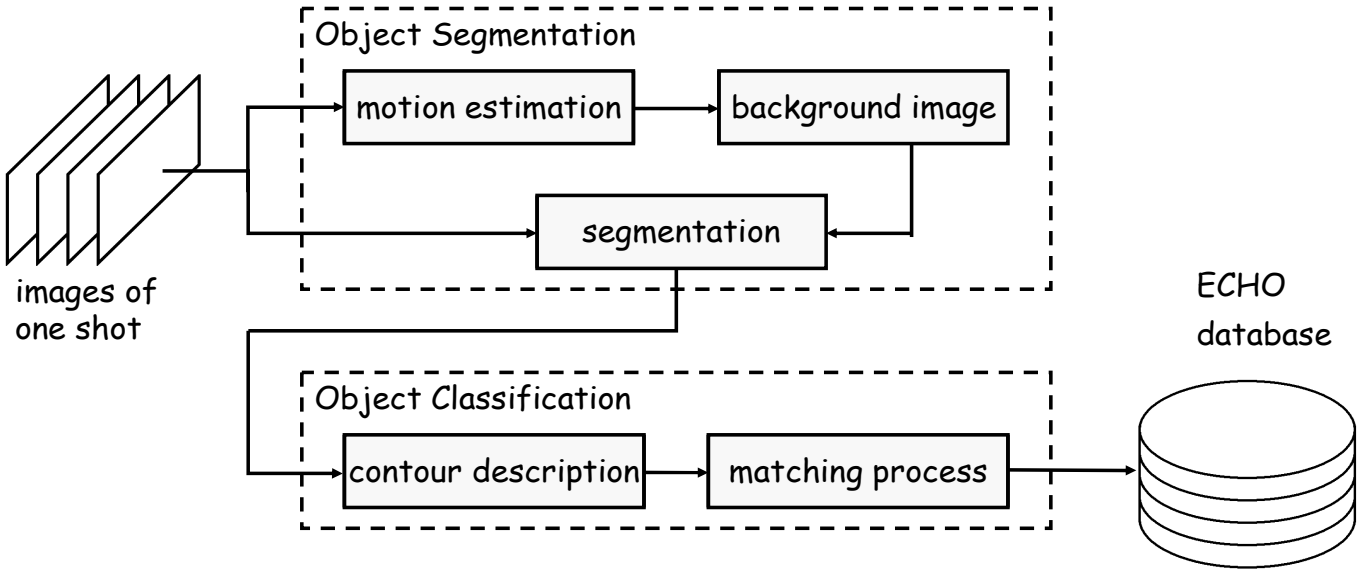
Speech recognition

- **The purpose of speech recognition is the generation of a transcript to be used as a support for retrieval**
- **Main functionality required**
  - Speaker independent
  - Multiple languages
  - Operating also with low quality audio
- **Does not require perfect recognition**
  - Retrieval quality is acceptable for W.E.R. up to 30-40%

Object detection and recognition

- **The system for moving-object recognition consists of two components, a *segmentation* module and a *classification* module.**
- **For each shot in the video, a background panorama image is constructed. The foreground objects in this background image are removed by means of temporal filtering (median).**
- **The object is segmented by comparing each frame of the video to the background image.**

Phases of Object detection and recognition

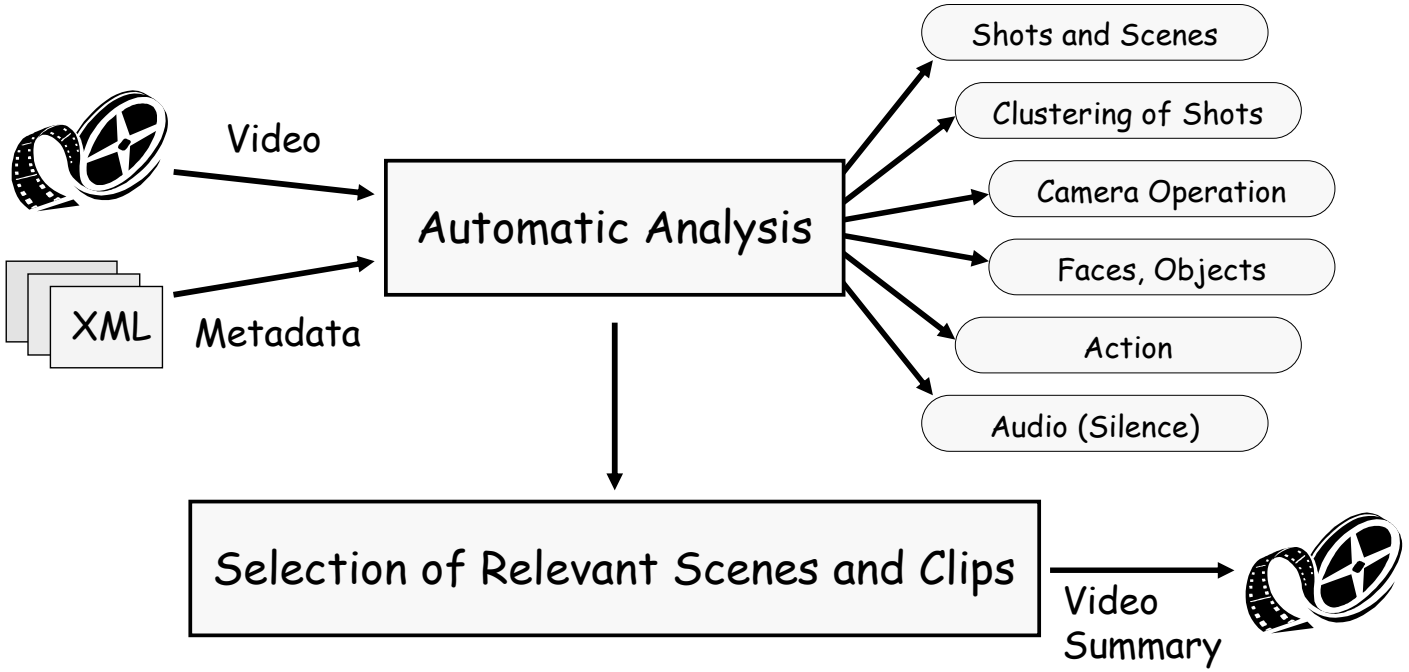


Example: Cars

Video abstract generation [1/2]

- **A video abstract is a part of a much longer video, which preserves the essential message of the original video.**
- **A video abstract does not change the presentation medium.**
- **The users get a quick overview of a much longer video.**
- **The video abstracting application will:**
  - Select relevant clips
  - Order these clips
  - Define a transition between two clips
  - Modify the audio track

Video abstract generation [2/2]



Representation of video content

- **Metadata are used to represent the video content in order**
  - To support video retrieval and navigation, as well as video management and processing
- **Simple attribute values can be used as metadata to represent the video content (e.g. Dublin Core)**
- **or complex representations can be used to describe content information extracted from videos (e.g. MPEG-7)**
- **Metadata can also provide a description of video structure**

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Retrieval functionality

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Retrieval functionality

- **Retrieval is based on queries expressed on metadata values.**
- **Both automatically extracted metadata, as well as metadata associated manually to the video can be used.**
- **The user may not distinguish between these metadata types; system behavior may be different**

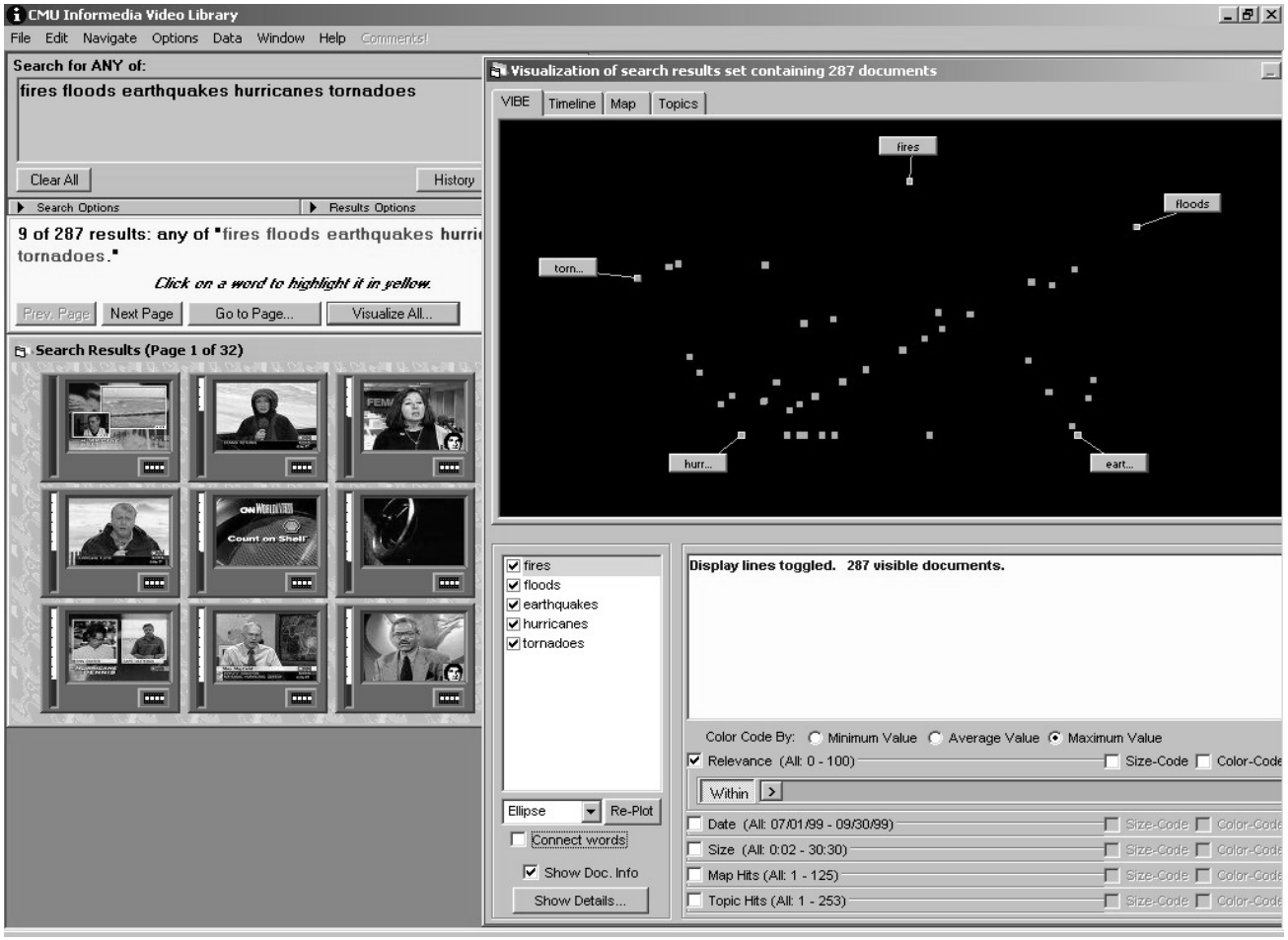
Type of queries

- **Queries can be expressed on**
  - Metadata associated to the entire video
    - ➔ **E.g.** *find b&w videos produced before II world war by Istituto Luce*
  - Metadata associated to video shots
    - ➔ **E.g.** *find a shot where the audio transcript contains the words "Attentato Banca Nazionale dell'Agricoltura"*
  - Metadata associated to single frames
    - ➔ **E.g.** *find a video that contains a frame similar to this image [the image is provided as an example]*
  - Any combination of the previous cases

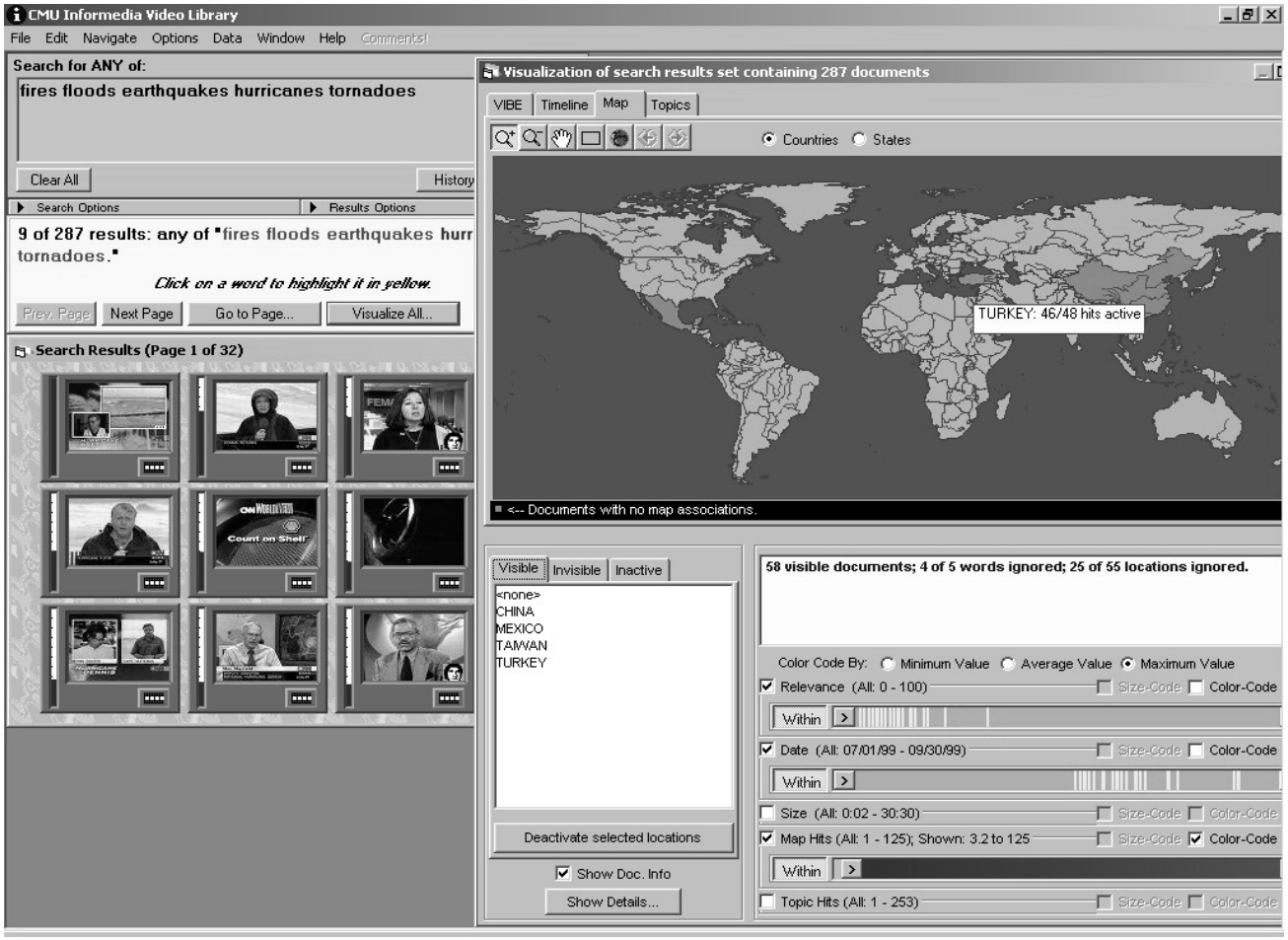
Retrieval characteristics

- **Retrieval is based on an approximate match between the query and the retrieved videos. This is mainly the case when imprecise query elements are used (e.g. free text, images)**
- **Retrieved videos are returned to the user in decreasing relevance order, possibly indicating the degree of relevance of the retrieved items.**
- **Due to the imprecision of the method (i.e. some of the retrieved items are not relevant for the user and some relevant items are not retrieved), it is helpful to have a query refinement and a relevance feedback mechanism.**

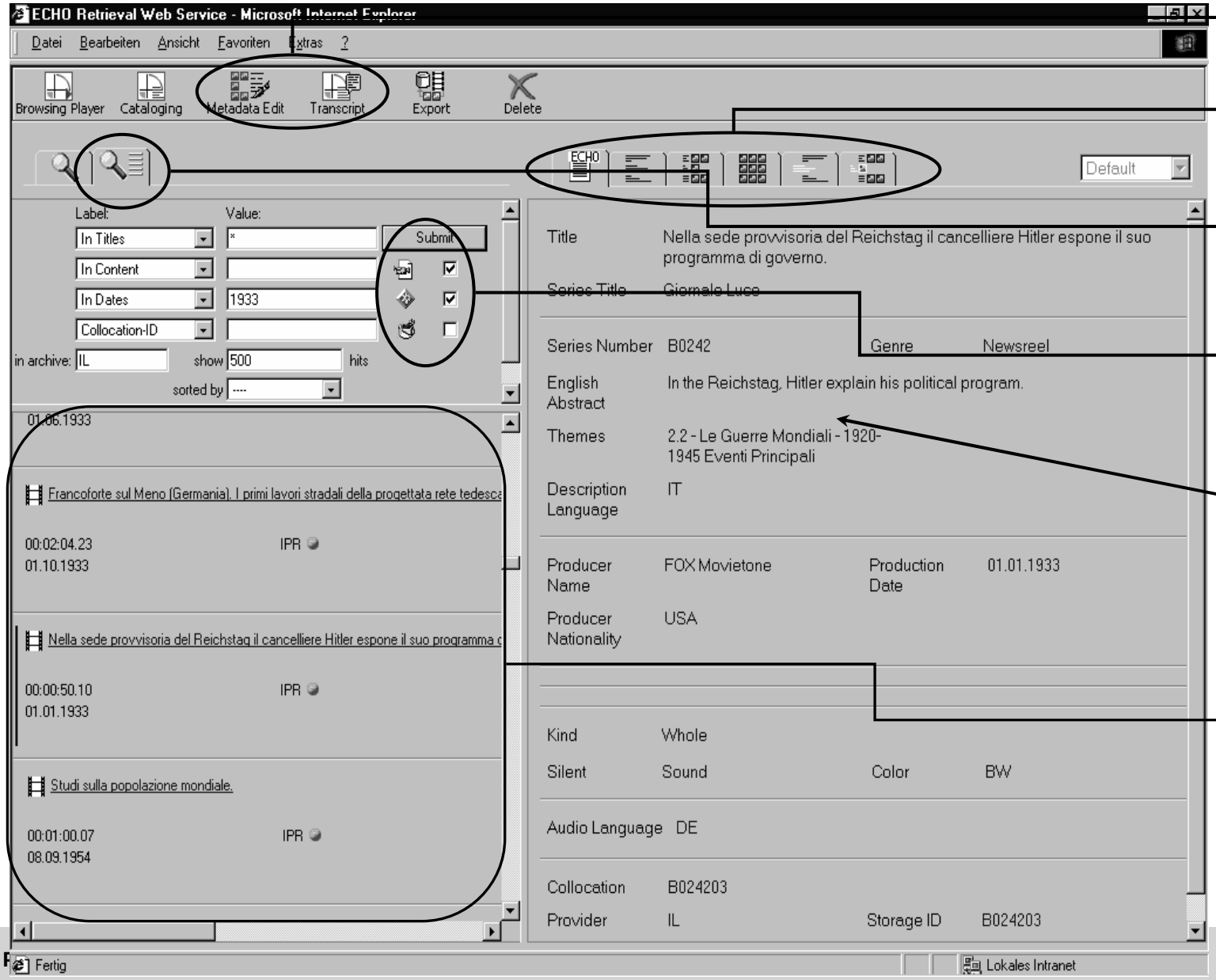
Informedia – an example



Informedia – an example



ECHO Retrieval Interface



Integration of Clients and Services in GUI

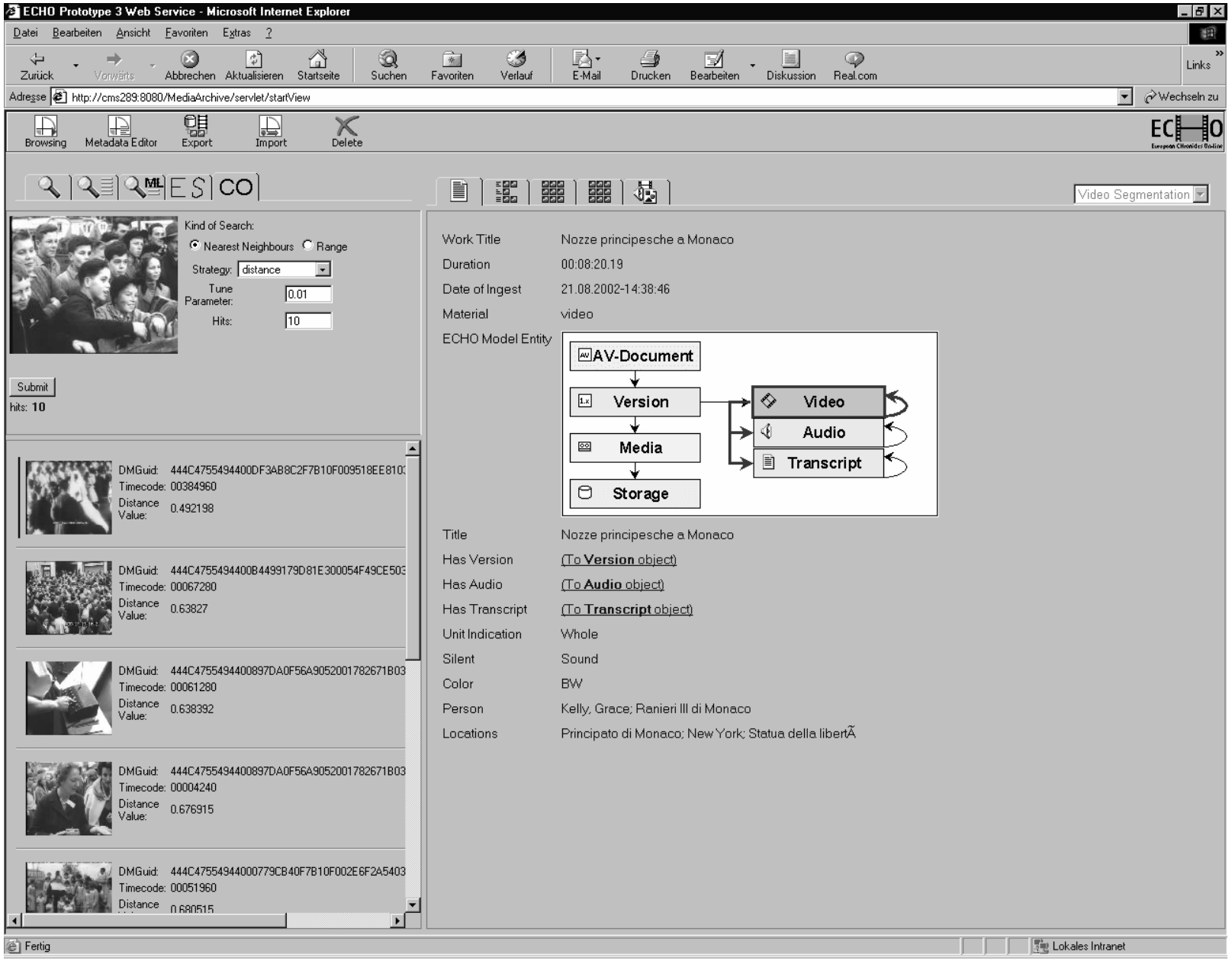
Views on the material

Attribute Search Retrieval interface

Search for category level of material (Work, Expression, Manifestation, Item)

Detailed view on an item corresponding to the full ECHO data model (structures, links, ...)

List of retrieved items


ECHO Prototype 3 Web Service - Microsoft Internet Explorer
Datei Bearbeiten Ansicht Favoriten Extras ?
Zurück Vorwärts Abbrechen Aktualisieren Startseite Suchen Favoriten Verlauf E-Mail Drucken Bearbeiten Diskussion Real.com Links
Adresse http://cms289:8080/MediaArchive/servlet/startView Wechseln zu
Browsing Metadata Editor Export Import Delete
ECHO
Kind of Search:
Nearest Neighbours Range
Strategy: distance
Tune Parameter: 0.01
Hits: 10
Submit
hits: 10
DMGuid: 444C4755494400DF3AB8C2F7B10F009518EE810
Timecode: 00384960
Distance Value: 0.492198
DMGuid: 444C4755494400B4499179D81E300054F49CE503
Timecode: 00067280
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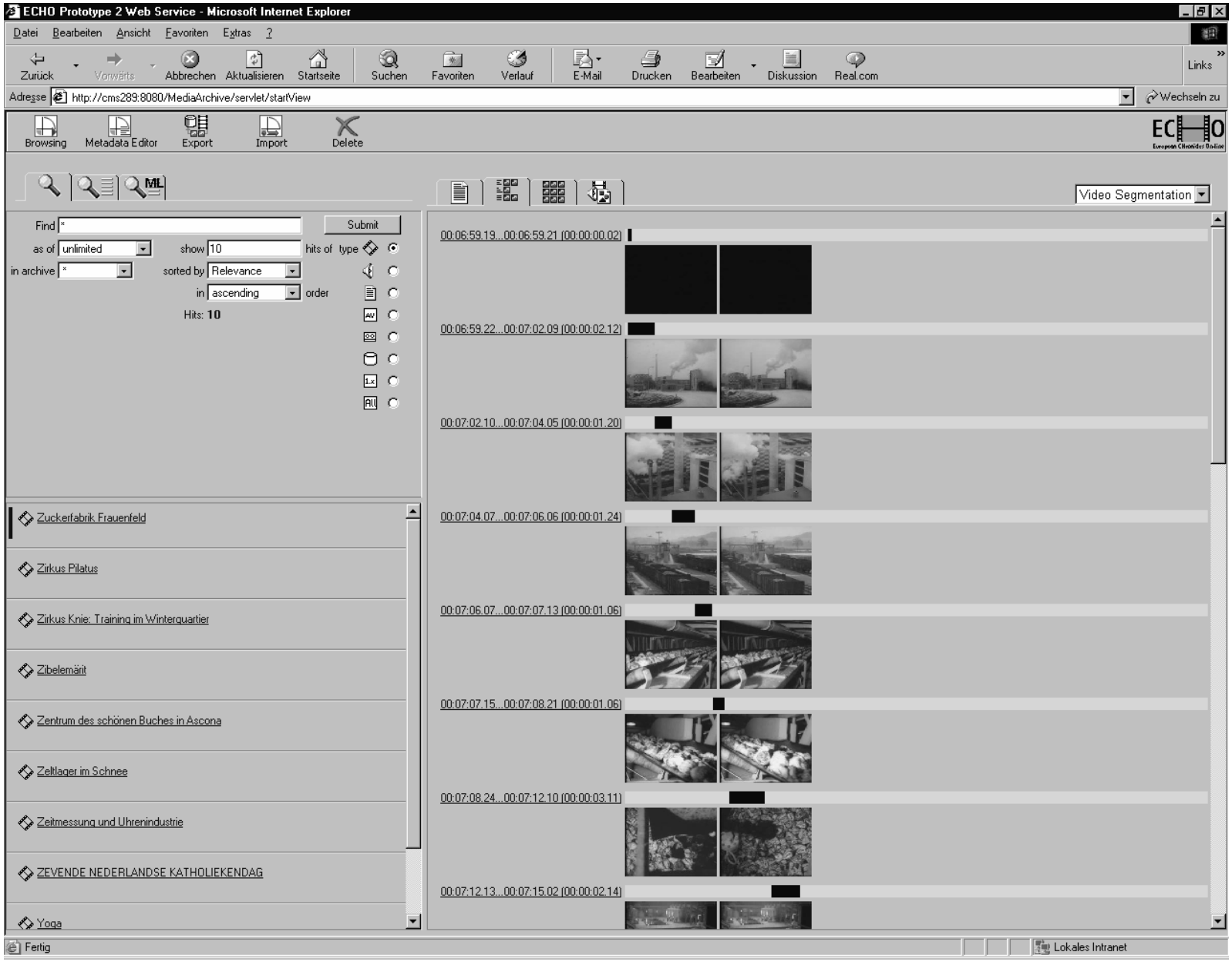
Timecode: 00051960
Distance
Video Segmentation
Work Title Nozze principesche a Monaco
Duration 00:08:20.19
Date of Ingest 21.08.2002-14:38:46
Material video
ECHO Model Entity
AV-Document
Version
Media
Storage
Video
Audio
Transcript
Title Nozze principesche a Monaco
Has Version (To Version object)
Has Audio (To Audio object)
Has Transcript (To Transcript object)
Unit Indication Whole
Silent Sound
Color BW
Person Kelly, Grace; Ranieri III di Monaco
Locations Principato di Monaco; New York; Statua della libertÃ
Fertig
Lokales Intranet


ECHO Prototype 2 Web Service - Microsoft Internet Explorer
Datei Bearbeiten Ansicht Favoriten Extras ?
Zurück Vorwärts Abbrechen Aktualisieren Startseite Suchen Favoriten Verlauf E-Mail Drucken Bearbeiten Diskussion Real.com Links
Adresse http://cms289:8080/MediaArchive/servlet/startView Wechseln zu
Browsing Metadata Editor Export Import Delete
Video Segmentation
Find * Submit
as of unlimited show 10 hits of type
in archive * sorted by Relevance
in ascending order
Hits: 10
Zuckerfabrik Frauenfeld
Zirkus Pilatus
Zirkus Knie: Training im Winterquartier
Zibelemärit
Zentrum des schönen Buches in Ascona
Zeltlager im Schnee
Zeitmessung und Uhrenindustrie
ZEVENDE NEDERLANDSE KATHOLIEKENDAG
Yoga
00:06:59.19...00:06:59.21 (00:00:00.02)
00:06:59.22...00:07:02.09 (00:00:02.12)
00:07:02.10...00:07:04.05 (00:00:01.20)
00:07:04.07...00:07:06.06 (00:00:01.24)
00:07:06.07...00:07:07.13 (00:00:01.06)
00:07:07.15...00:07:08.21 (00:00:01.06)
00:07:08.24...00:07:12.10 (00:00:03.11)
00:07:12.13...00:07:15.02 (00:00:02.14)
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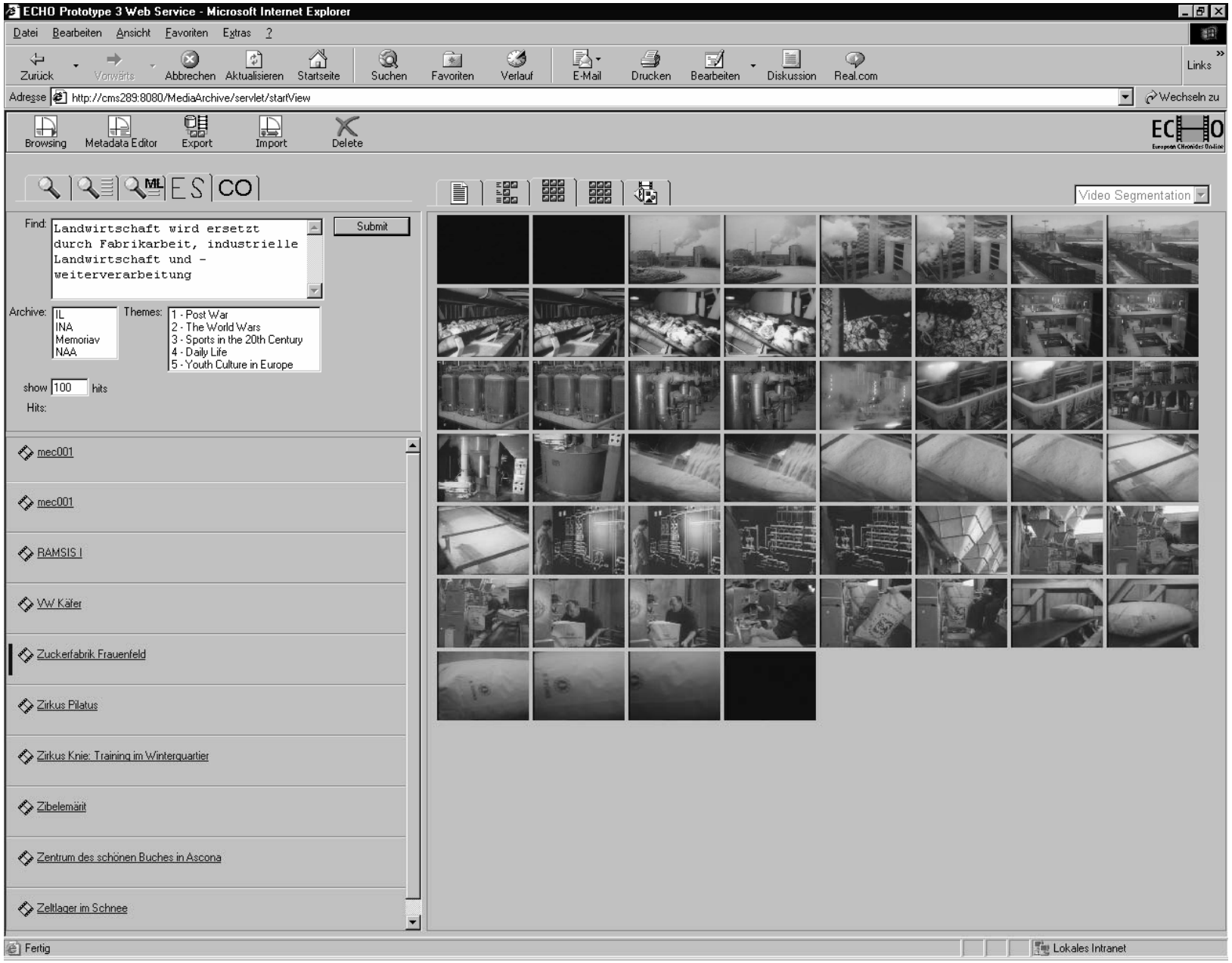
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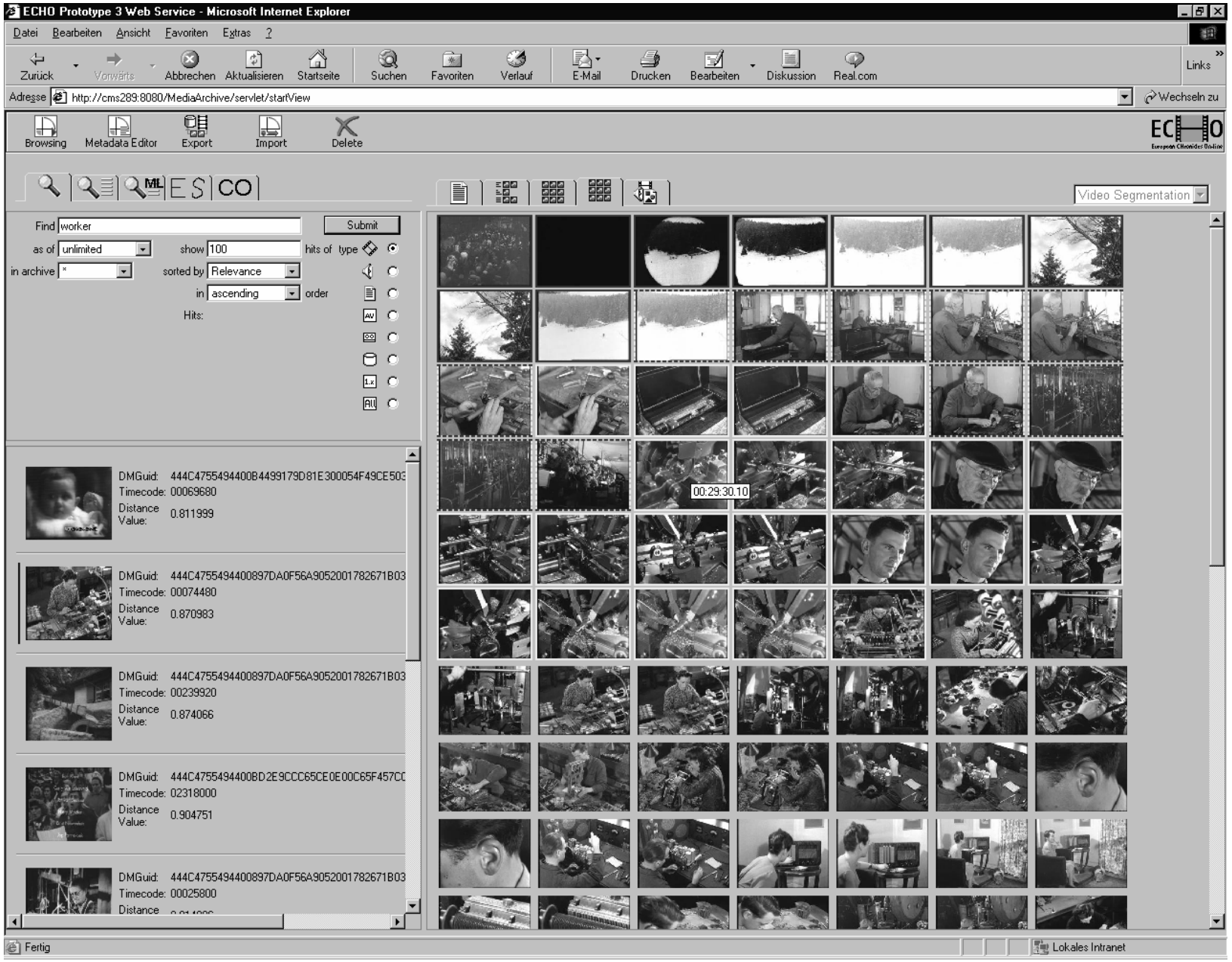
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