A Semantic Multimedia Web: Create, Annotate, Present and Share your Media

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CWI, Semantic Media Interfaces
Learning Objectives

• Understand multimedia applications workflow
  – Take the canonical processes of media production model

• Explore various multimedia metadata formats
  – Be aware of the advantages and limitations of various models
  – Know the interoperability issues and understand COMM, a Core Ontology for Multimedia

• Discuss exploratory interfaces based on rich multimedia metadata semantics
  – Know how to link and expose your data on the web
  – See various multimedia presentation interfaces
Agenda

1. Understanding Multimedia Applications Workflow
   - CeWe Color Photo Book creation application
   - Vox Populi argumentation-based video sequences generation
   - Canonical Processes of Media Production

2. Semantic Annotation of Multimedia Content
   - Multimedia metadata formats: use cases and requirements
   - Multimedia metadata interoperability issues
   - MPEG-7 based ontologies
   - COMM: A Core Ontology for MultiMedia

3. Semantic Search and Presentation of Multimedia Content
   - Link your data!
   - Searching and Browsing Multimedia Semantic Datasets with Cliopatria
Understanding Multimedia Applications Workflow

• Identify and define a number of canonical processes of media production

• Community effort
  
  – 2005: Dagstuhl seminar
  – 2008: Multimedia Systems Journal Special Issue (core model and companion system papers)
    editors: Frank Nack, Zeljko Obrenovic and Lynda Hardman
Overview of Canonical Processes

- Premeditate
- Create
- Annotate
- Package
- Construct Message
- Organize
- Query
- Publish
- Distribute
Example 1: CeWe Color PhotoBook

• Application for authoring digital photo books
• Automatic selection, sorting and ordering of photos
  – Context analysis methods: timestamp, annotation, etc.
  – Content analysis methods: color histograms, edge detection, etc.
• Customized layout and background
• Print by the European leader photo finisher company
  
  http://www.cewe-photobook.com
CeWe Color PhotoBook Processes

- My winter ski holidays with my friends

Premeditate

Construct Message
CeWe Color PhotoBook Processes

- Package
- Create
CeWe Color PhotoBook Processes
CeWe Color PhotoBook Processes

- Query

- Organize

![Image of CeWe Color PhotoBook processes](image-url)
CeWe Color PhotoBook Processes

- Publish
- Distribute
CeWe Color PhotoBook Processes
Example 2: Vox Populi Video Sequences Generation

Stefano Bocconi, Frank Nack

• **Interview with America**
  video footage with interviews and background material about the opinion of American people after 9-11
  [http://www.interviewwithamerica.com](http://www.interviewwithamerica.com)

• Example question:
  *What do you think of the war in Afghanistan?*

  “I am never a fan of military action, in the big picture I don’t think it is ever a good thing, but I think there are circumstances in which I certainly can’t think of a more effective way to counter this sort of thing...”
Vox Populi Premeditate Process

• Analogous to the pre-production process in the film industry
  – Static versus dynamic video artifact
• Output
  – Script, planning of the videos to be captured
  – Questions to the interviewee prepared
  – Profiles of the people interviewed:
    education, age, gender, race
  – Locations where the interviews take place
Vox Populi Annotations

• Contextual
  – Interviewee (social), locations

• Descriptive
  – Question asked and transcription of the answers
  – Filmic continuity, examples:
    • gaze direction of speaker (left, centre, right)
    • framing (close-up, medium shot, long shot)

• Rhetorical
  – Rhetorical Statement
  – Argumentation model: Toulmin model
Vox Populi Statement Annotations

• Statement formally annotated:
  - `<subject> <modifier> <predicate>`
  - E.g. “war best solution”

• A thesaurus containing:
  - Terms on the topics discussed (155)
  - Relations between terms: similar (72), opposite (108), generalization (10), specialization (10)
  - E.g. war opposite diplomacy
Toulmin Model

Claim

Data

Qualifier

Warrant

Backing

Condition

Concession

57 Claims, 16 Data, 4 Concessions, 3 Warrants, 1 Condition
Vox Populi Query Interface

- **Question**: What do you think of the Afghanistan war?
- **Interviewee**: Camaroun Parking Guard at Stamford
  Lawyer in Harvard
- **Opinion**: War in Afghanistan - Pro

- **Position**
  - **First Character**
  - **Second Character**

- **Age**
  - Middle
  - Old
  - Teenager
  - Young

- **Education**
  - High Educated
  - Low Educated
  - Medium Educated

- **Employment**
  - High Income, Job
  - Low Income, Job
  - Middle Income, Job
  - Retired
  - Student

- **GeoLocation**
  - Not USA
  - USA

- **Race**
  - American Indian
  - Asian
  - Black
  - Hispanic
  - White

- **Religion**
  - Atheist
  - Christian
  - Muslim

- **Sex**
  - Female
  - Male

- **Strategy**
  - None
  - Create Clash
Vox Populi Organize Process

• Using the thesaurus, create a graph of related statements
  – nodes are the statements (corresponding to video segments)
    “war best solution”,
    “diplomacy best solution”,
    “war not solution”
  – edges are either support or contradict

![Graph diagram showing nodes and edges for statements.]
Result of Vox Populi Query

I am not a fan of military actions

I cannot think of a more effective solution

War has never solved anything

Two billions dollar bombs on tents

Publish

Distribute
Vox Populi Processes
Canonical Processes 101

• Canonical: reduced to the simplest and most significant form possible without loss of generality

• Formalization of each process in UML diagrams
  – Process
  – Process artifacts
  – Process actors
  – External world artifacts
Premeditate

- Process where initial ideas about media production are established
  - Design a photo book of my last holidays for my family
  - Create argument-based sequences of videos of interviews after September 11
Create Media Asset

- Process where media assets are captured, generated or transformed
Annotate

- Process where annotation is created
Semantic Annotate

• The annotation uses some controlled vocabularies
  - *Subject matter annotations of your photos*
  - *Rhetorical annotations in Vox Populi*
Package

- Process where process artifacts are logically and physically packed

- Any Process Artifact

- Input given by a user

- Multimedia Package

- Physical Package

- Logical Package
Query

• Process where a user retrieves a set of process artifacts based on a given query
Construct Message

• Process where an author specifies the message they wish to convey
  – "Our holiday was sporty, great weather and fun"
  – "Create clash about whether war is a good thing"
Organize

- Process where process artifacts are organized according to the message
  - **Organize a number of 2-page layouts in photobook**
  - **Use semantic graph to select related video clips to form linear presentation of parts of argument structure**
Publish

- Process where final content and user interface is created
Distribute

- Process where final interaction between end-users and produced media occurs
Canonical Processes Possible Flow

1. Premeditate
2. Create
3. Annotate
4. Package
5. Organize
6. Construct Message
7. Query
8. Publish
9. Distribute
Sum Up

• Community agreement, not “yet another model”
• Large proportion of the functionality provided by multimedia applications can be described in terms of this model
• Initial step towards the definition of open web-based data structures for describing and sharing semantically annotated media assets
Discussion

• Frequently asked questions
  – Complex processes
  – Interaction
  – Complex artifacts and annotations can be annotated

• Towards a more rigorous formalization of model
  – Relationship to foundational ontologies
  – Semantics of Annotations
Literature


• Special Issue on Canonical Processes of Media Production
  http://www.ifi.uio.no/MMSJ/upcomming.html
  http://www.cwi.nl/~media/projects/canonical/


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   - Vox Populi argumentative video sequences generation system
   - *The Canonical Processes of Media Production*

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   - Multimedia metadata interoperability issues
   - MPEG-7 based ontologies
   - *COMM: A Core Ontology for MultiMedia*

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The Importance of the Annotations
W3C Multimedia Semantics XG

http://www.w3.org/2005/Incubator/mmsem/
Managing Personal Photos

• Interoperable Image Metadata
  – Combining EXIF, MPEG-7, IPTC and DIG35 metadata using RDF and OWL schemas
Facetting Music Songs

- Interoperable Music and Social Metadata
  - ID3 Tags + low-level features extraction + lastFM recommendations + FOAF profiles + ...
  - Auto-construction of playlist (similar bit rate), Personalization, Browsing music store
Multimedia: Description methods

ISO

- MPEG-1
- MPEG-2
- MPEG-4
- MPEG-7
- MPEG-21

W3C

- Query: SPARQL
- Data interchange: RDF
- URI
- Unicode
- RDF-S
- RDF
- Ontology: OWL
- Rules: RIF
- Proof
- Unifying Logic
- Trust
- Crypto
MPEG-7: a multimedia description language?

- ISO standard since December of 2001
- Main components:
  - Descriptors (Ds) and Description Schemes (DSs)
  - DDL (XML Schema + extensions)
- Concern all types of media

Part 5 – MDS
Multimedia Description Schemes
MPEG-7 and the Semantic Web

- MDS Upper Layer represented in RDFS
  - 2001: Hunter
  - Later on: link to the ABC upper ontology
- MDS fully represented in OWL-DL
  - 2004: Tsinaraki et al., DS-MIRF model
- MPEG-7 fully represented in OWL-DL
  - 2005: Garcia and Celma, Rhizomik model
  - Fully automatic translation of the whole standard
- MDS and Visual parts represented in OWL-DL
  - 2007: Arndt et al., COMM model
  - Re-engineering MPEG-7 using DOLCE design patterns
Requirements [aceMedia, MMSEM XG]

• MPEG-7 compliance
  – Support most descriptors (decomposition, visual, audio)

• Syntactic and Semantic interoperability
  – Shared and formal semantics represented in a Web language (OWL, RDF/XML, RDFa, etc.)

• Separation of concerns
  – Domain knowledge versus multimedia specific information

• Modularity
  – Enable customization of multimedia ontology

• Extensibility
  – Enable inclusion of further descriptors (non MPEG-7)
### MPEG-7 Based Ontologies

<table>
<thead>
<tr>
<th>Foundational Ontologies</th>
<th>Hunter</th>
<th>DS-MIRF</th>
<th>Rhizomik</th>
<th>COMM</th>
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<td>ABC</td>
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<td>DOLCE</td>
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<th>MDS+Visual</th>
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<th>Applications</th>
<th>Digital Libraries</th>
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<th>Digital Rights</th>
<th>MM Analysis</th>
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Common Scenario

The "Big Three" at the Yalta Conference (Wikipedia)
Common Scenario: Tagging Approach

- Localize a region
  - Draw a bounding box, a circle around a shape

- Annotate the content
  - Interpret the content
  - Tag: Winston Churchill, UK Prime Minister, Allied Forces, WWII

The "Big Three" at the Yalta Conference (Wikipedia)
Common Scenario: SW Approach

- Localize a region
  - Draw a bounding box, a circle around a shape

- Annotate the content
  - Interpret the content
  - Link to knowledge on the Web

:Reg1 foaf:depicts dbpedia:WinstonChurchill
dbpedia:Churchill rdfs:label "Winston Churchill"
dbpedia:Churchill rdf:type foaf:Person

The "Big Three" at the Yalta Conference (Wikipedia)
Hunter's MPEG-7 Ontology

The Big Three at the Yalta Conference


mpeg7:image
mpeg7:depicts
mpeg7:spatial_decomposition
mpeg7:Polygon
mpeg7:Coords
5 25 10 20 15 15 10 10 5 15
mpeg7:StillRegion
mpeg7:Depict
mpeg7:DominantColor
rgb(25,255,255)
dbpedia:Churchill

Reg1
mpeg7:StillRegion
mpeg7:Depict
mpeg7:DominantColor
rgb(25,255,255)
dbpedia:Churchill

mpeg7:image
mpeg7:depicts
mpeg7:spatial_decomposition
mpeg7:Polygon
mpeg7:Coords
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mpeg7:DominantColor
rgb(25,255,255)
dbpedia:Churchill

Reg1
mpeg7:StillRegion
mpeg7:Depict
mpeg7:DominantColor
rgb(25,255,255)
dbpedia:Churchill
Rhizomik MPEG-7 Ontology

The Big Three at the Yalta Conference


mpeg7:MediaLocator

mpeg7:SegmentType

rdf:type

dbpedia:Churchill

mpeg7:Semantic

mpeg7:SubRegion

mpeg7:Polygon

mpeg7:Coords

5 25 10 20 15 10 10 5 15"^^xsd:string
COMM: Fragment Identification


dns:realized-by

core:image-data
dns:setting

dns:plays
loc:region-locator-descriptor
dns:defines
loc:bounding-box
data:has-rectangle

5 25 10 20 15 10 10 5 15

loc:spatial-mask
role
dns:played-by

core:semantic-annotation
dns:defines

foaf:Person
dns:played-by

dbpedia:Churchill

rdf:type

core:semantic-label
role
Comparison

• Link with domain semantics
  - Hunter: ABC model + mpeg7:depicts relationship
  - DS-MIRF: Domain ontologies needs to subclass the general MPEG-7 categories
  - Rhizomik: Use the mpeg7:semantic relationship
  - COMM: Semantic Annotation pattern

• MPEG-7 coverage
  - Hunter: extension of the MPEG-7 visual descriptors
  - COMM:
    • Formalization of the context of the annotation
    • Representation of the method (algorithm) that provides the annotation
Comparison

• Modeling Decisions:
  - DS-MIRF and Rhizomik: 1-to-1 translation from MPEG-7 to OWL/RDF
  - Hunter: Simplification and link to the ABC upper model
  - COMM: NO 1-to-1 translation
    • Need for patterns: use DOLCE, a well designed foundational ontology as a modeling basis

• Scalability:

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</tr>
</thead>
<tbody>
<tr>
<td>Triples</td>
<td>11</td>
<td>27</td>
<td>20</td>
<td>19</td>
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</tbody>
</table>
Summary
Semantic descriptions of non-textual media available on the web can be used to facilitate retrieval and presentation of media assets and documents containing them. While technologies for multimedia semantic descriptions already exist, there is as yet no formal description of a high quality multimedia ontology that is compatible with existing (semantic) web technologies. We propose **COMM - A Core Ontology for Multimedia** based on both the MPEG-7 standard and the DOLCE foundational ontology.

The research is partially supported by the European Commission under contracts:
- FP6-027026, Knowledge Space of semantic inference for automatic annotation and retrieval of multimedia content - **K-Space**.
- FP6-026978, **X-Media** Integrated Project.

People
- Thomas Franz
- Steffen Staab
- Raphael Troncy
- Richard Arndt
Scenario: Image

The "Big Three" at the Yalta Conference (Wikipedia)

- Localize a region (bounding box)
- Annotate the content (interpretation)
  - Tag: Winston Churchill, UK Prime Minister, Allied Forces, WWII
  - Link to knowledge on the Web

```
:Reg1 foaf:depicts dbpedia:WinstonChurchill
dbpedia:Churchill rdfs:label "Winston Churchill"
dbpedia:Churchill rdf:type foaf:Person
```
Scenario: Video

- Localize a region
- Annotate the content
  - Tag: G8 Summit, Heiligendamm, 2007
  - Link to knowledge on the Web

A history of G8 violence (video) (© Reuters)
EU Summit, Gothenburg, 2001

:Seq1 foaf:depicts dbpedia:34th_G8_Summit
:Seq4 foaf:depicts dbpedia:EU_Summit
geo:Heilegendamm skos:broader geo:Germany
Research Problem

The "Big Three" at the Yalta Conference (Wikipedia)

A history of G8 violence (video)
(© Reuters)

- Multimedia objects are complex
  - Compound information objects, fragment identification
- Semantic annotation
  - Subjective interpretation, context dependent
- Linked data principle
  - Open to reuse existing knowledge

⇒ MPEG-7
⇒ D&S | OIO
⇒ RDF
COMM: Design Rationale

• Approach:
  – NO 1-to-1 translation from MPEG-7 to OWL/RDF
  – Need for patterns: use DOLCE, a well designed foundational ontology as a modeling basis

• Design patterns:
  – Ontology of Information Objects (OIO)
    • Formalization of information exchange
    • Multimedia = complex compound information objects
  – Descriptions and Situations (D&S)
    • Formalization of context
    • Multimedia = contextual interpretation (situation)

• Define multimedia patterns that translate MPEG-7 in the DOLCE vocabulary
COMM: Core Functionalities

- Most important MPEG-7 functionalities:
  - **Decomposition** of multimedia content into segments
  - **Annotation** of segments with metadata
    - Administrative metadata: creation & production
    - Content-based metadata: audio/visual descriptors
    - Semantic metadata: interface with domain specific ontologies

⇒ Note that all are subjective and context dependent situations
Definition of design patterns for **decomposition** and **annotation** based on D&S and OIO

- MPEG-7 describes digital data (*multimedia information objects*) with digital data (*annotation*)
- *Digital data* entities are information objects
- Decompositions and annotations are *situations* that satisfy the rules of a method or algorithm
COMM: Decomposition Pattern

D&S / OIO

description
information-object
role
method
situation

structured-data-description
digital-data
processing-role
algorithm
segment-decomposition

descriptor
multimedia-dat
output-role
input-role
segmentation-algorithm

localization-descriptor
mask-role
plays

MPEG-7
COMM: Annotation Pattern

D&S / OIO

satisfies
defines

situation

method

algorithm

processing-role

output-role

input-role

structured-data-description
digital-data

multimedia-data

role

description

information-object

descriptor

annotation-role

setting

annotation

MPEG-7
COMM: Semantic Pattern

Domain Ontologies
COMM: Modules

Annotation Pattern

Decomposition Pattern
Example 1: Fragment Identification


dns:realized-by

core:image-data

dns:plays

dns:played-by

dns:defines

dns:defines

loc:region-locator-descriptor

loc:spatial-mask-role

loc:bounding-box

5 25 10 20 15 15 10 10 5 15"^^xsd:string

data:has-rectangle

www.w3.org/2000/10/swap/core

www.w3.org/2000/10/swap/data

www.w3.org/2000/10/swap/image
Example 1: Region Annotation

[Diagram showing relationships between entities and properties such as core:image-data, loc:bounding-box, dns:realized-by, core:semantic-annotation, dns:defines, foaf:Person, rdf:type, etc.]

- dns:realized-by
- core:image-data
- loc:bounding-box: 5 25 10 20 15 10 10 5 15"^^xsd:string
- dns:plays
- dns:played-by
- dns:defines
- core:semantic-label-role
- core:semantic-annotation
- dns:setting
- loc:region-locator-descriptor
- foaf:Person
- rdf:type
Example 2: Fragment Identification

dns:realized-by

core:image-data
dns:plays

dns:defines
loc:media-time-descriptor

loc:temporal-mask-role
dns:played-by

loc:media-time-point

"1:21"^^xsd:time
data:has-time
Example 2: Sequence Annotation

dns:realized-by

core:image-data
dns:setting
dns:plays

dns:played-by

dns:defines

core:semantic-annotation
dns:defines
dns:played-by

tgn:Sweden

loc:temporal-mask-role
data:has-time
"1:21"^^xsd:time

data:has-time

tgn:Gothenburg

loc:media-time-point
dns:defines

tgn:Sweden

loc:media-time-descriptor
Implementation

• COMM fully formalized in OWL DL
  - Rich axiomatization, consistency check (Fact++v1.1.5)
  - OWL 2.0: qualified cardinality restrictions for number restrictions of MPEG-7 low-level descriptors

• JAVA API available
  - MPEG-7 class interface for the construction of metadata at runtime
KAT Annotation Tool
Evaluation

• Applied Domains
  - Knowledge management for multimedia documents
  - Driving multimedia analysis process
  - Generate new interfaces for browsing multimedia content

• Scalability
  - 4 minutes video,
    TREC Vid metadata expressed in COMM
    • 250 K statements
  - Reasoning in large scale applications
Literature


• Raphaël Troncy, Oscar Celma, Suzanne Little, Roberto Garcia, Chrisa Tsinaraki: MPEG-7 based Multimedia Ontologies: Interoperability Support or Interoperability Issue? In 1st Workshop on Multimedia Annotation and Retrieval enabled by Shared Ontologies (MARESO'2007), Genoa, Italy, December 2007.
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A Giant Graph Open to the World

<rdf:Description rdf:about="Ganesh.jpg">
  <dc:title>An image of the Elephant Ganesh</dc:title>
  <dc:creator>Raphaël Troncy</dc:creator>
</rdf:Description>

- Annotate the content (interpretation)
  Elephant, Ganesh, Thailande, Holidays, Chiang Mai

- Link to knowledge on the Web
  :img foaf:depicts dbpedia:Ganesh
dbpedia:Ganesh rdfs:label "Vinayaka"
dbpedia:Ganesh skos:altlabel "Ganapati"
dbpedia:Ganesh rdf:type wn:synset-Deities-noun-1
dbpedia:Ganesh owl:sameas wn:synset-Ganesh-noun-1
Linking Open Data Project

- Expose open datasets in RDF
- Set RDF links among the data items for different datasets
- Over 2 billion triples, 3 millions links (March 2008)

http://richard.cyganiak.de/2007/10/lod/
DBpedia

• DBpedia is a community effort to:
  – extract structured "infobox" information from Wikipedia
  – interlink DBpedia with other datasets on the Web
DBpedia

Extracting Infobox Data

http://en.wikipedia.org/wiki/Calgary

<http://dbpedia.org/resource/Calgary>
  dbpedia:native_name "Calgary"
  dbpedia:altitude "1048"
  dbpedia:population_city "988193"
  dbpedia:populationMetro "1079310"
  mayor_name
    dbpedia:Dave_Bronconnier
  governing_body
    dbpedia:Calgary_City_Council
...

- Altogether 9,100,000 RDF triples
  extracted from 754,000 infoboxes

Christian Bizer et al. DBpedia – Querying Wikipedia Like a Database (May 11, 2007)
Automatic Links Among Open Datasets

Processors can switch automatically from one to the other ...
Take Home Message

• Reuse what is there
  – Of course, one could create RDF data manually … … but that is unrealistic on a large scale
  – Goal is to generate RDF data automatically when possible and "fill in" by hand only when necessary
    • service to get RDF from flickr images
      http://www.kanzaki.com/works/2005/imgdsc/flickr2rdf
    • service to get RDF from XMP
      http://www.ivan-herman.net/cgi-bin/blosxom.cgi/WorkRelated/SemanticWeb/xmpeextract.html

• Expose what you make
  open your data to anyone who might use it
This cultural search engine will give you access to artworks from several museum collections. Type a keyword, for example: Derain, calligraphy, or 1867.
Semantic Browsing of Multimedia News

• Goal:
  - Provide an environment for searching and browsing contextualized multimedia news information

• Method:
  - Semantic processing of multimedia news items
  - Link news items with knowledge on the web

• Datasets:
  - News stories: Jun/Jul 2006 (en/fr) newsfeed, AFP ± 90,000 items
  - Photos: 2006 football world cup, AFP ± 2,500 items
  - Video: Jun/Jul 2006 TV News (fr), INA ± 30 items
Problems

- No integration of media (stories, photo, video)
- Little (or no) context in the news presentation
- Lack of interoperability in the current workflow
Metadata Conversion

NAR Schema → NewsCodes Controlled Vocabularies → Broadcaster Schema

FOAF + SKOS alignment

W3C OWL W3C RDF
Semantic Processing

Named Entity Recognition

Domain Ontologies

NAR Ontology
NewsCodes
Thesaurus

spout
Semantic Processing

- NAR Ontology
- NewsCodes
- Thesaurus

Knowledge Assisted Analysis

Concept Detectors

Domain Ontologies
Semantic Processing

NAR Ontology
NewsCodes
Thesaurus

Named Entity Recognition

Domain Ontologies

Linked Data

RDF Powered

This news search engine will give you access to news items kindly provided by AFP.
Type a keyword, for example: Amsterdam, Lyon or Zidane.
Future Work

• Integrate the video browser in the interface
  – Metadata conversion and interoperability
  – Address temporal fragments of the video
  – Visualize videoclips in the interface

• Enrich metadata with visual analysis
  – Apply K-Space concept detectors on visual media
  – Provide new dimensions (facets) for browsing the data
    • Ex: distinguish field images vs stadium and street images with a grass detector for the World Cup dataset

• Evaluation, Evaluation, Evaluation …
Literature


- W3C Video on the Web Activity, April 2008 http://www.w3.org/2008/01/video-activity.
Thanks for your attention

http://www.cwi.nl/~media/www08/