THESEUS Project -

Semantic and Image Processing Technologies and its Applications

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Outline

THESEUS
Forschungsprogramm für eine neue internetbasierte Wissensinfrastruktur

- Introduction
- Facts about THESEUS and its organisation
- Use Cases
- Core Technology Cluster (CTC)
- Image and video processing technologies
- Application scenario 1: Digitization with automatic quality assessment
- Application scenario 2: Automatic content analysis & metadata generation
- Evaluation of Core Technologies
- Summary

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Semantic technologies enable the Internet of Services

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ELECTRONIC MARKET PLACES

Aggregation and offering of services

Trading of services via central portals

Semantic technologies for offering and and usage of services

Classical services

Medical Care

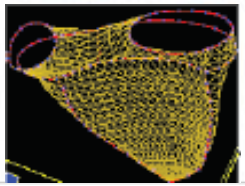
Public service

Insurance

New, automated services

B2B services

Media Services



Services for medical technologies

THESEUS Facts

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Some facts about THESEUS:

- Number of partners: 22 (30, including 9 Fraunhofer institutes)
  extended by 30 additional partners (SME program from 2010 on)
- Start: ≈ mid 2007
- Duration: 5 years
- Budget: ≈ 200 Mio. €
- Funding: ≈ 100 Mio. €
- Web: http://theseus-programm.de

THESEUS Partners *

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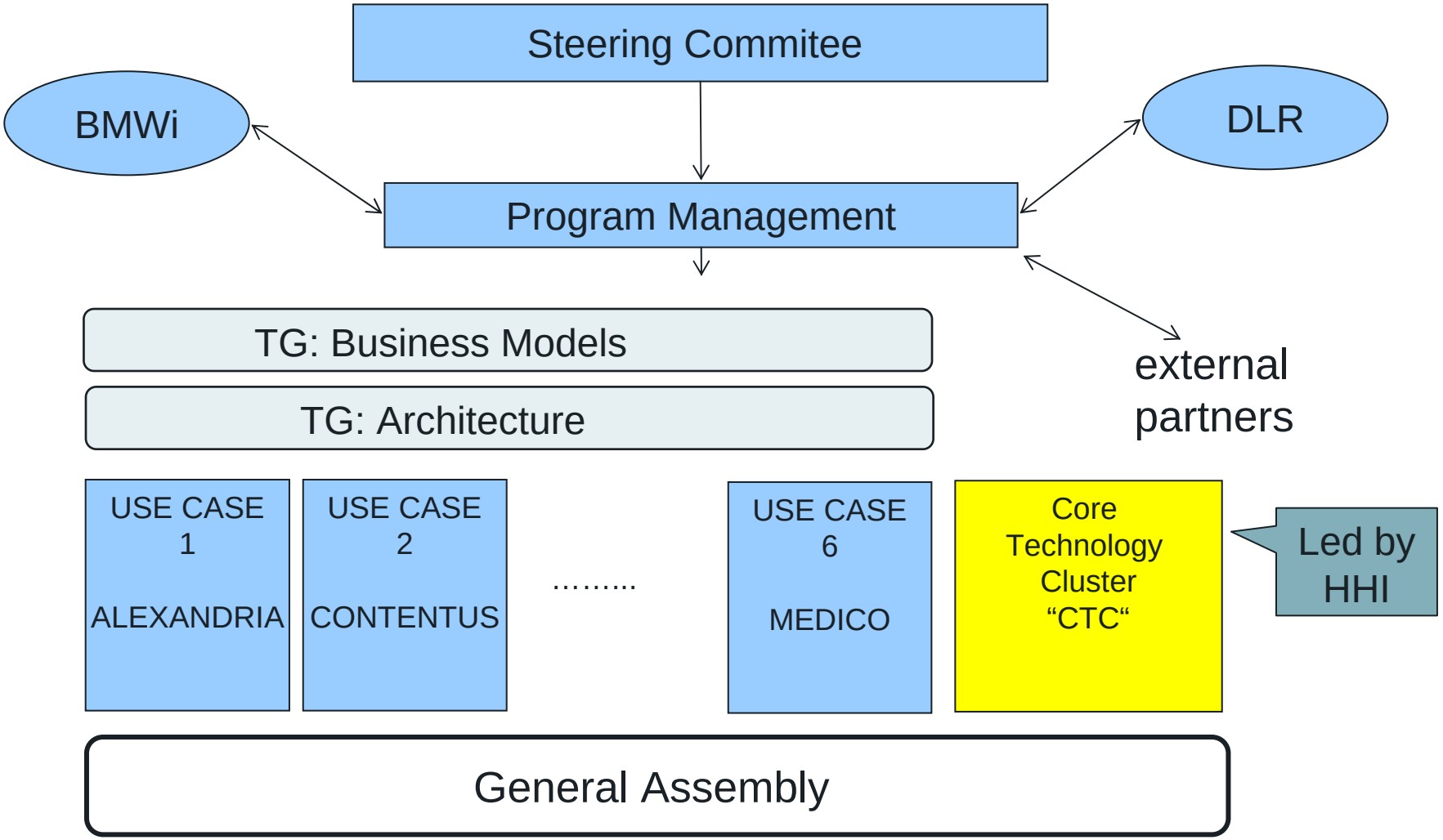
Deutsche Nationalbibliothek
Deutsche Thomson OHG (DTO)
Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI GmbH)
empolis GmbH
Festo AG
Fraunhofer-Gesellschaft (FIRST, HHI, IAIS, IAO, IDMT, IIS, IITB, IGD, ITWM)
Friedrich-Alexander-Universität Erlangen
FZI Forschungszentrum Informatik
Institut für Rundfunktechnik GmbH (IRT)
intelligent views gmbh
Ludwig-Maximilians-Universität (LMU)
moresophy GmbH
mufin GmbH
neofonie GmbH
ontoprise GmbH
SAP AG
Siemens AG
Technische Universität Darmstadt
Technische Universität Dresden
Technische Universität München
Universität Karlsruhe (TH)
Verband Deutscher Maschinen- und Anlagebau e.V. (VDMA)

Coordinator: empolis GmbH

***SME program partners not included**

THESEUS Organisation



THESEUS: 6 Use Cases

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TEXO
New web-based service industry

PROCESSUS
Increase of competitiveness by process knowledge

MEDICO
New means for medical diagnostics

ORDO
Optimisation of innovation process

ALEXANDRIA
Knowledge management for everybody

CONTENTUS
Provisioning of cultural heritage for everybody

Need:

Medical imaging scanners generate today large amounts of heterogeneous data that is only indexed by keywords.

There is a clear **need for advanced image searching technologies that would provide direct access to image information**.

Vision:

Empower the medical imaging content-stakeholders by providing direct, semantic access to medical image databases with applications in personalised healthcare, biomedical research, and training.

MEDICO Objectives

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Objectives:

- **Build the next generation of intelligent, scalable and robust search engines for the medical imaging domain:**
- Construct innovative, hierarchical information representations that will facilitate flexible image queries
- Formally address the intrinsic constraints of the medical imaging domain to define the space of queries
- Integrate higher level knowledge that will help explaining different semantic views in medical imaging: structure, function, and disease
- Create new synergies between semantics and image understanding

MEDICO: Impact on Clinical Workflow

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Use Case: A radiologist wants to find similar patient data in order to determine whether he should send a patient with moderate stenosis of the proximal RCA determined by CT angiography to cardiac catheterization:

Today:

- set filter “modality = angiography”
- set filter “procedure = coronary angiography”
- read report to look for moderate RCA stenosis (<10% of the cases in the list)
- check if coronary CT scan exists
- load CT and angiography scans,
- manually locate stenosis

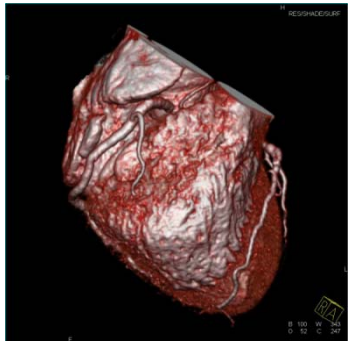
→ The radiologist does the relevant part of the search manually

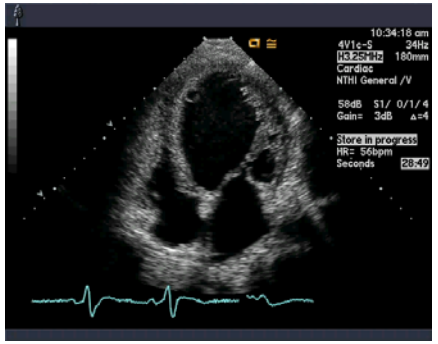
→ If the radiologists looks for something that is not part of the report, he/she even has to search in the images directly

Tomorrow:

Formulate query

“Show similar patients with CT and corresponding coronary angiography scans with a moderate stenosis of the proximal RCA”





RCA = Right coronary artery Stenosis = Abnormal narrowing in a blood vessel

Vision:

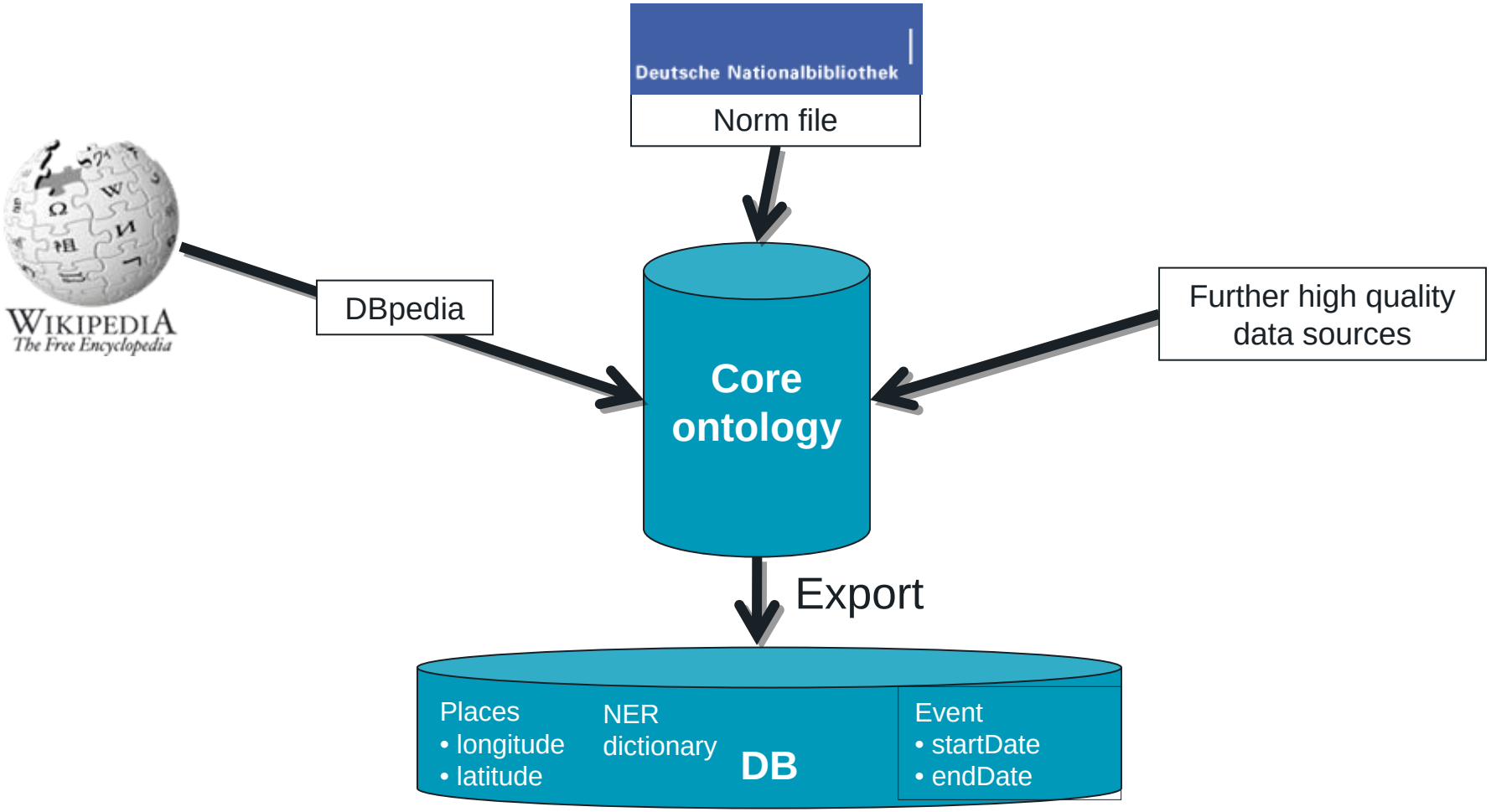
Creation of a user oriented knowledge platform

- Generation of a comprehensive knowledge base **(ontology)** extracted from existing knowledge sources
- Development of new **navigation and search concepts** in large data bases and semantic networks
- Use of automatically extracted and user generated content to **expand the ontology**
- Creation of a **Community** for specific domains

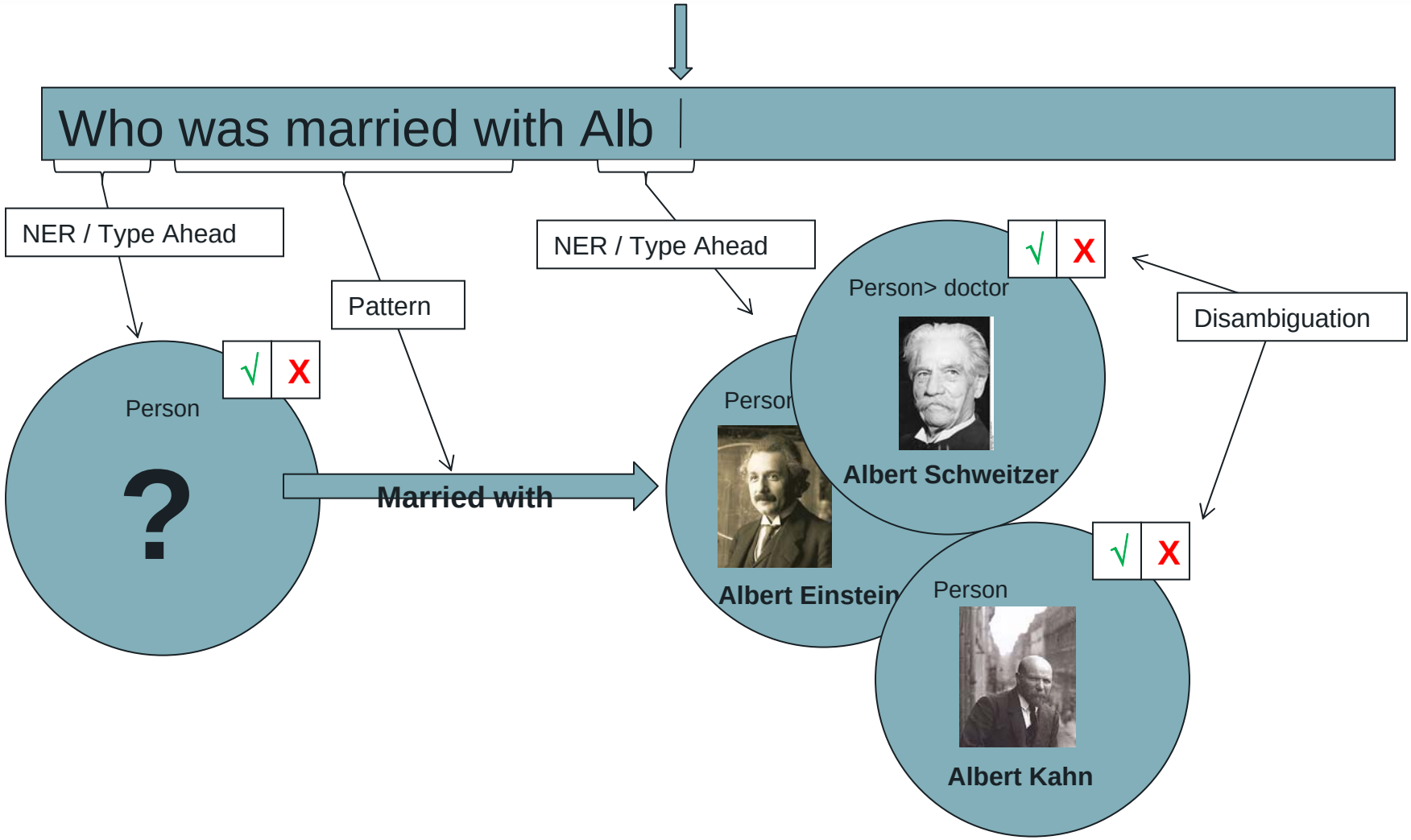
Application scenario “history”:

- „Famous“ persons, creations, places and events (relevant to history)

Ontology design



Semantic GUI – Search



Semantic GUI – FIND

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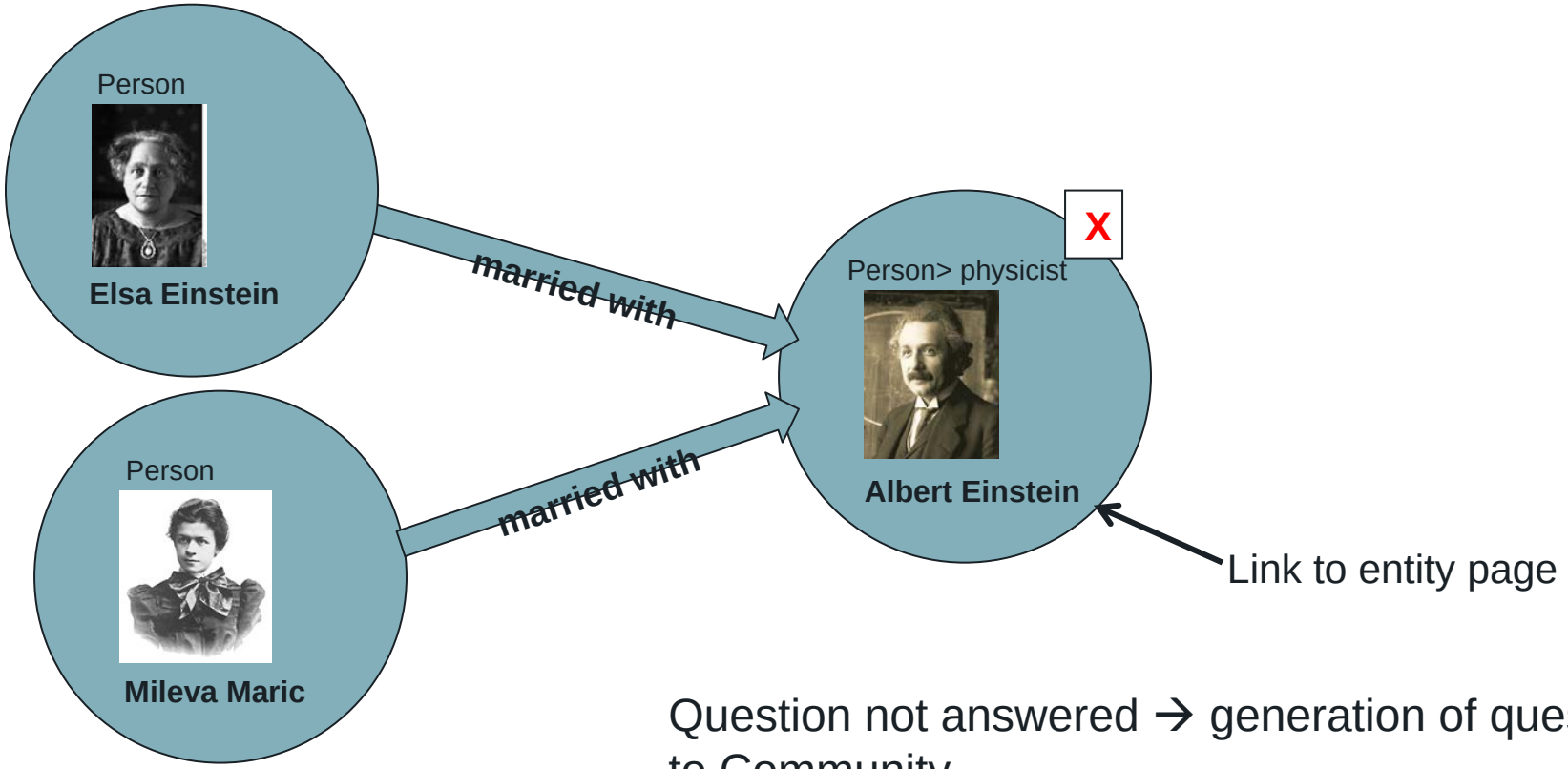
Who was married with Albert Einstein?



Question not answered → generation of question to Community

CONTENTUS – Next generation multimedia archives

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- Content is digital
  - Processing, administration and provisioning of heterogeneous multimedia content is day-by-day business
  - All media are available in high quality
- Always connected
  - Access anytime at any place
  - Media production and publication as act of linking
  - Resources are not added to the knowledge base … they are created in the knowledge base
- Always posted
  - The searched information finds the user
- Journey through knowledge bases
  - through cultural and scientific collections, dictionaries and media archives
  - Interactive exploration of topics

CONTENTUS approach

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CONTENTUS processing chain

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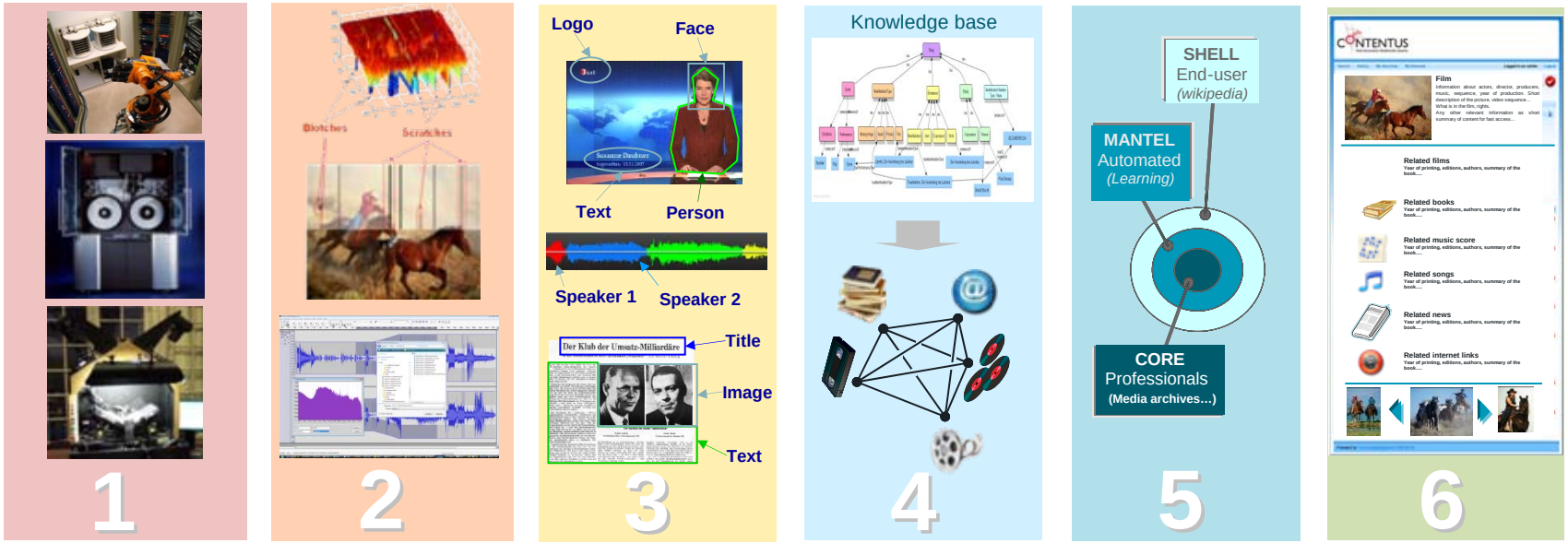
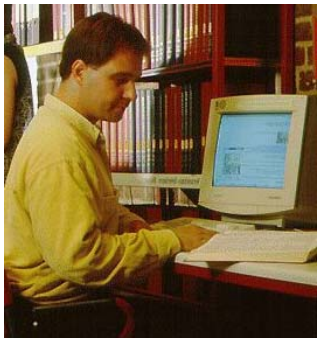


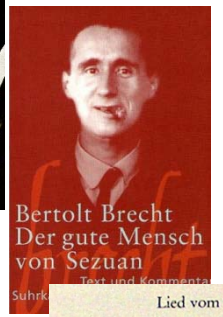
CONTENTUS - Next Generation Multimedia Library



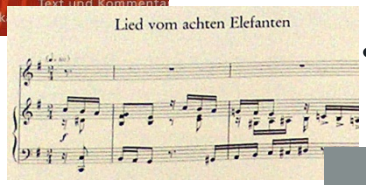
Users searches for
„*Der gute Mensch von Sezuan*“
(Dessau / Brecht)

Finds

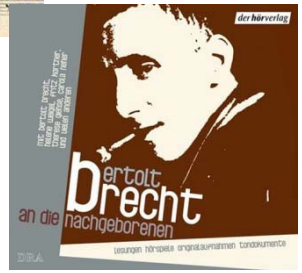
- **Pictures, videos of Paul Dessau and Bert Brecht**
  => QBE, QBK, Semantic Linking



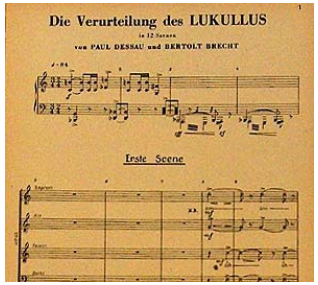
- **Books, texts of Bert Brecht**
  => QBE, Semantic Linking



- **sheets of music of Paul Dess**
  => Semantic Linking



- **music**
  => QBE, SL, Fingerprinting



Potato System

musicload
powered by T-Online

iTunes

Further pictures or videos of GDR composers or authors

Further books or texts of or about Bert Brecht or GDR authors

Futher sheets of music of and about Paul Dessau or GDR composers

Links to archives or music of commercial providers

Core Technology Cluster (CTC) – Overview

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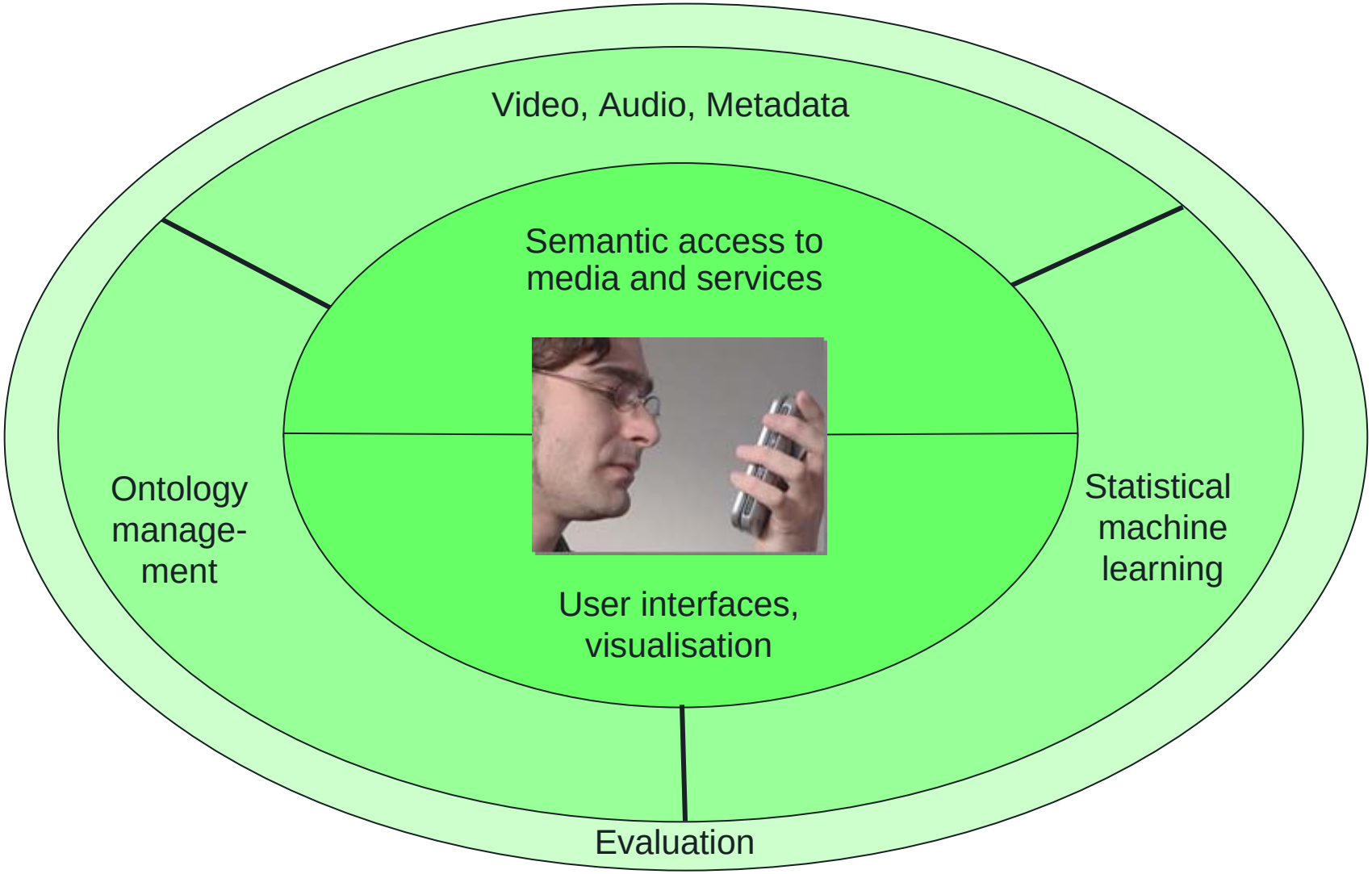

CTC Workpackages

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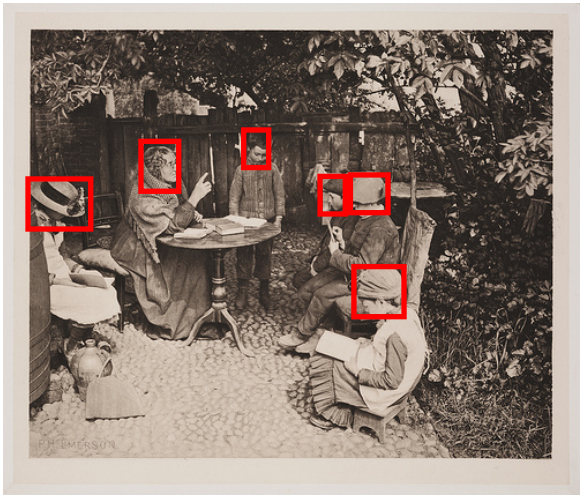
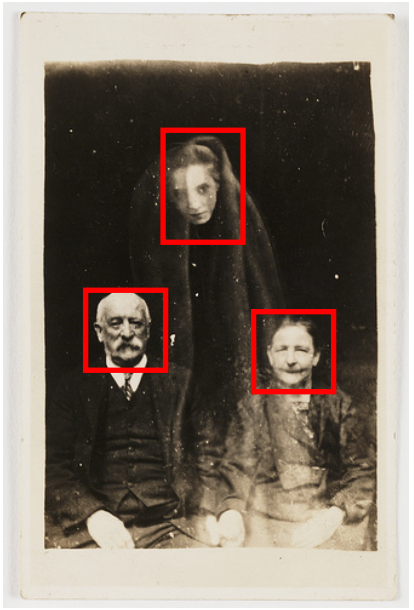
- WP1: CTC Management (HHI)
- WP2: Video, Audio, Metadata, Platforms (HHI)
- WP3: Ontology Management (FZI)
- WP4: Semantic Access to Media and Services (DFKI)
- WP5: User Interface, Visualization (IGD)
- WP6: Statistical Machine Learning (Siemens)
- WP8: Evaluation (IDMT)

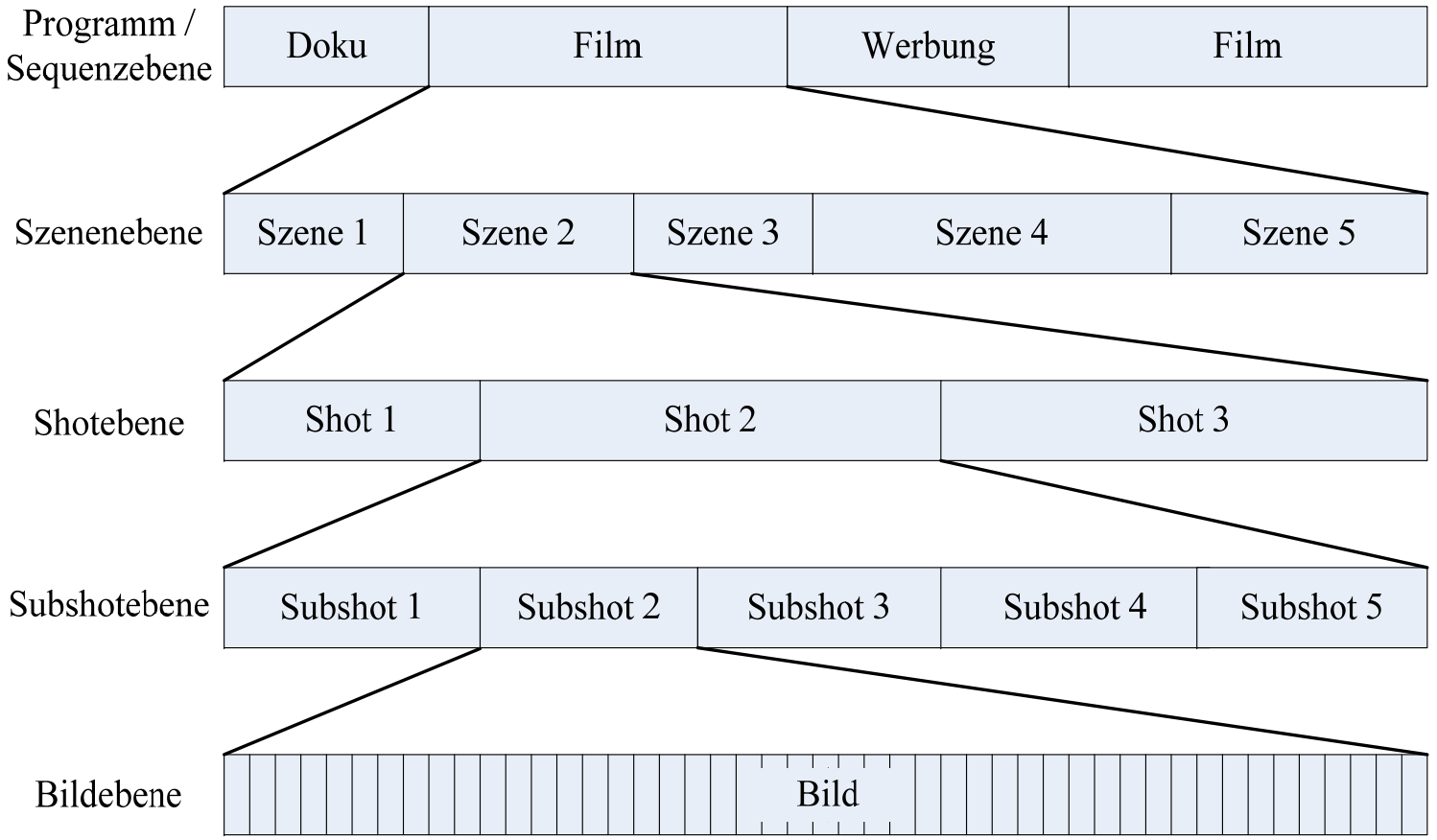
Image Recognition: Face Detection





- Face detection
- Face tracking in videos

Video Recognition: Temporal Segmentation



program -> scene -> shot -> subshot -> picture

Video Recognition: Temporal Segmentation

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program / clip level

At the laboratory

Geologist exploring stones and cavities

scene level

Exploring and drilling in the field

At the laboratory

Exploring and drilling in the field

Back at the laboratory

Meeting with project sponsors

Portrait of scientist in his office

Back at the laboratory

Meeting with project sponsors

Portrait of scientist in his office

Video Recognition: Temporal Segmentation

Geologist exploring stones and cavities

At the laboratory

Exploring and drilling in the field

Back at the laboratory

Meeting with project sponsors

Portrait of scientist in his office

Video Segmentation for object-based metadata extraction

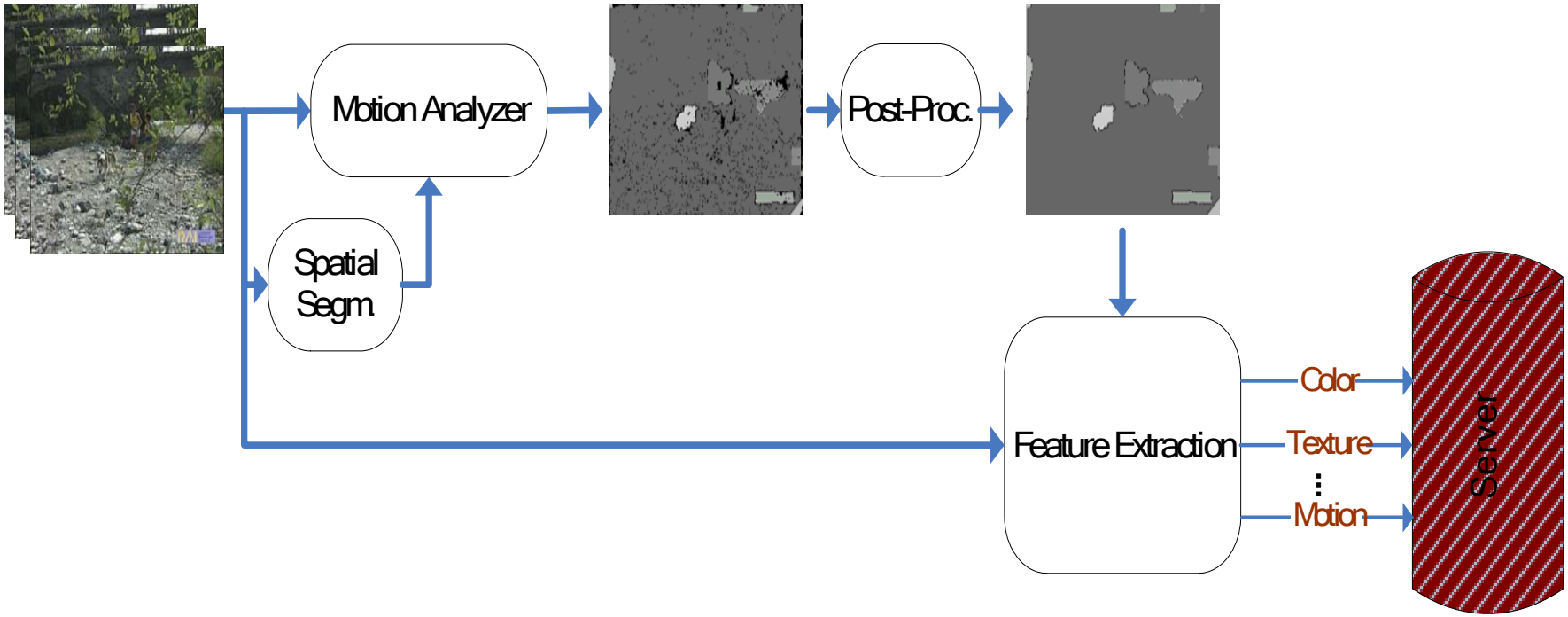

Image Recognition

- Segmentation
  - Based on spatial clues
- Low-level descriptor generation for segments
  - MPEG-7 descriptors
    - Scalable color descriptor
    - Edge histogram
  - Further descriptors (non-standardized)

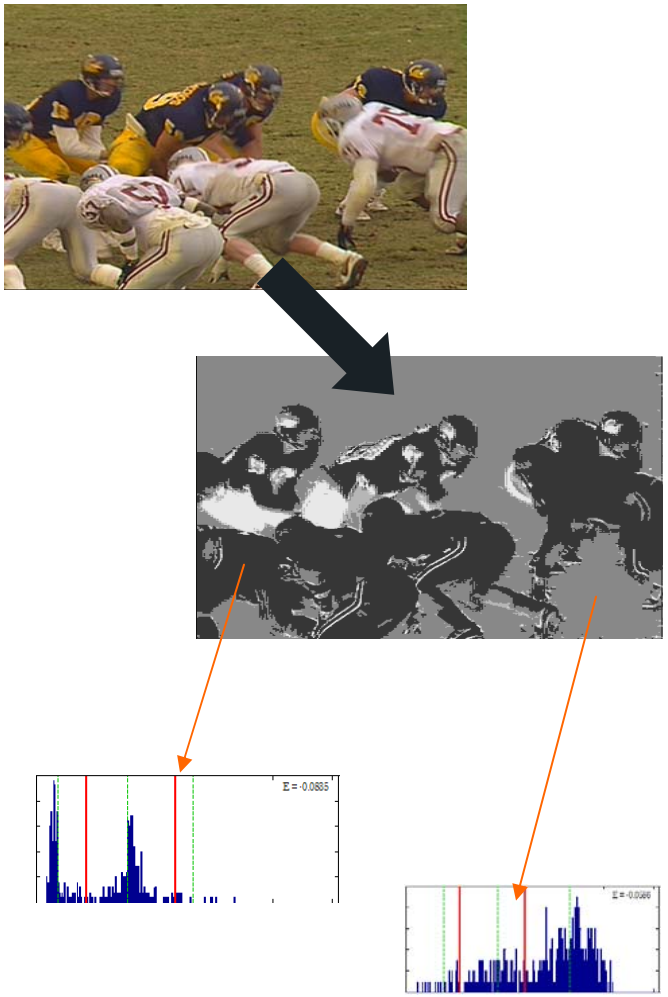

Image Recognition: Semantic Classification

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- Indoor vs. Outdoor
- Landscape
- Vegetation
- Beach

Video Recognition: Genre Detection

film

news

commercials

cartoons

Video Recognition: Hierarchical metadata model

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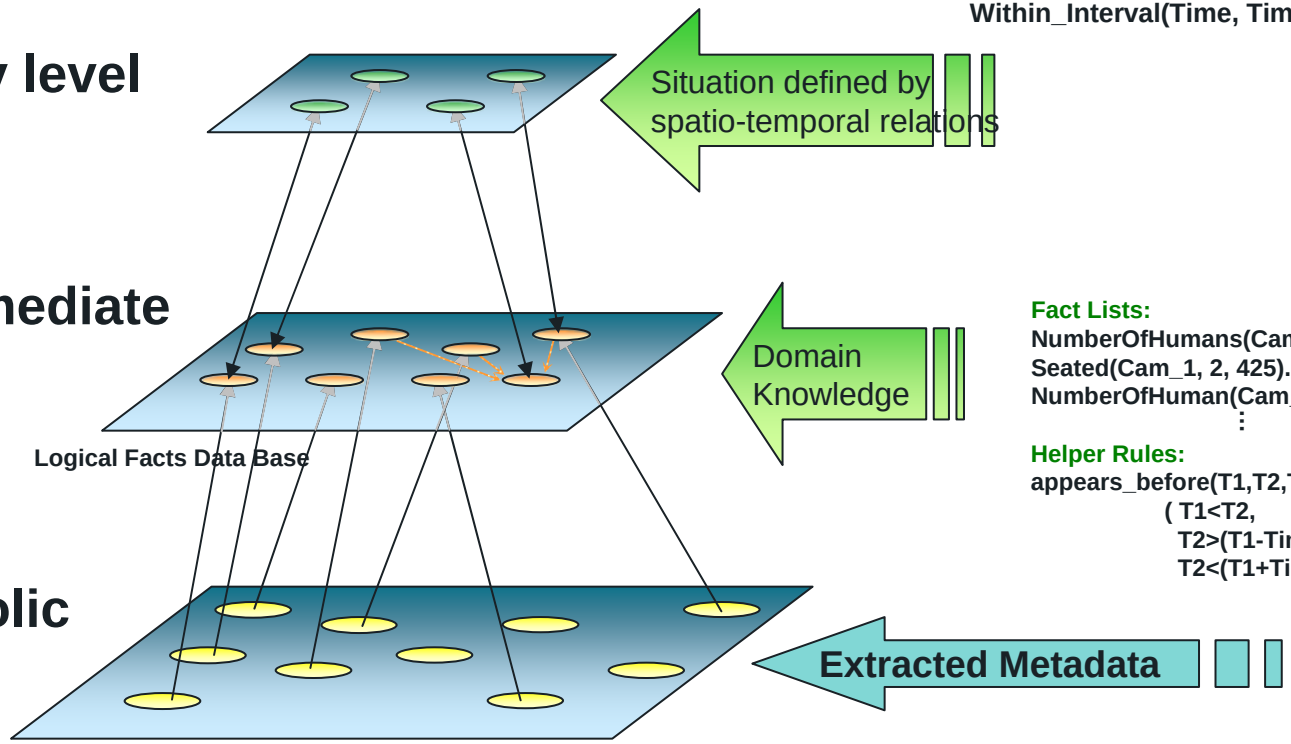
Query compsition:

Query(CamID, Time) ← NumberOfHumans(CamID, “mainarea”, Num, Time),
Num < 4,
not(seated(CamID, _, Time1),
Within_Interval(Time, Time1, 100).



Fact Lists:
NumberOfHumans(Cam_1, “mainarea”, 4, 325).
Seated(Cam_1, 2, 425).
NumberOfHuman(Cam_1, “leftmachine”, 4, 325).
⋮

Helper Rules:
appears_before(T1,T2,TimeDiff),
(T1<T2,
T2>(T1-TimeDiff),
T2<(T1+TimeDiff)).

Automatic Picture Quality Assessment

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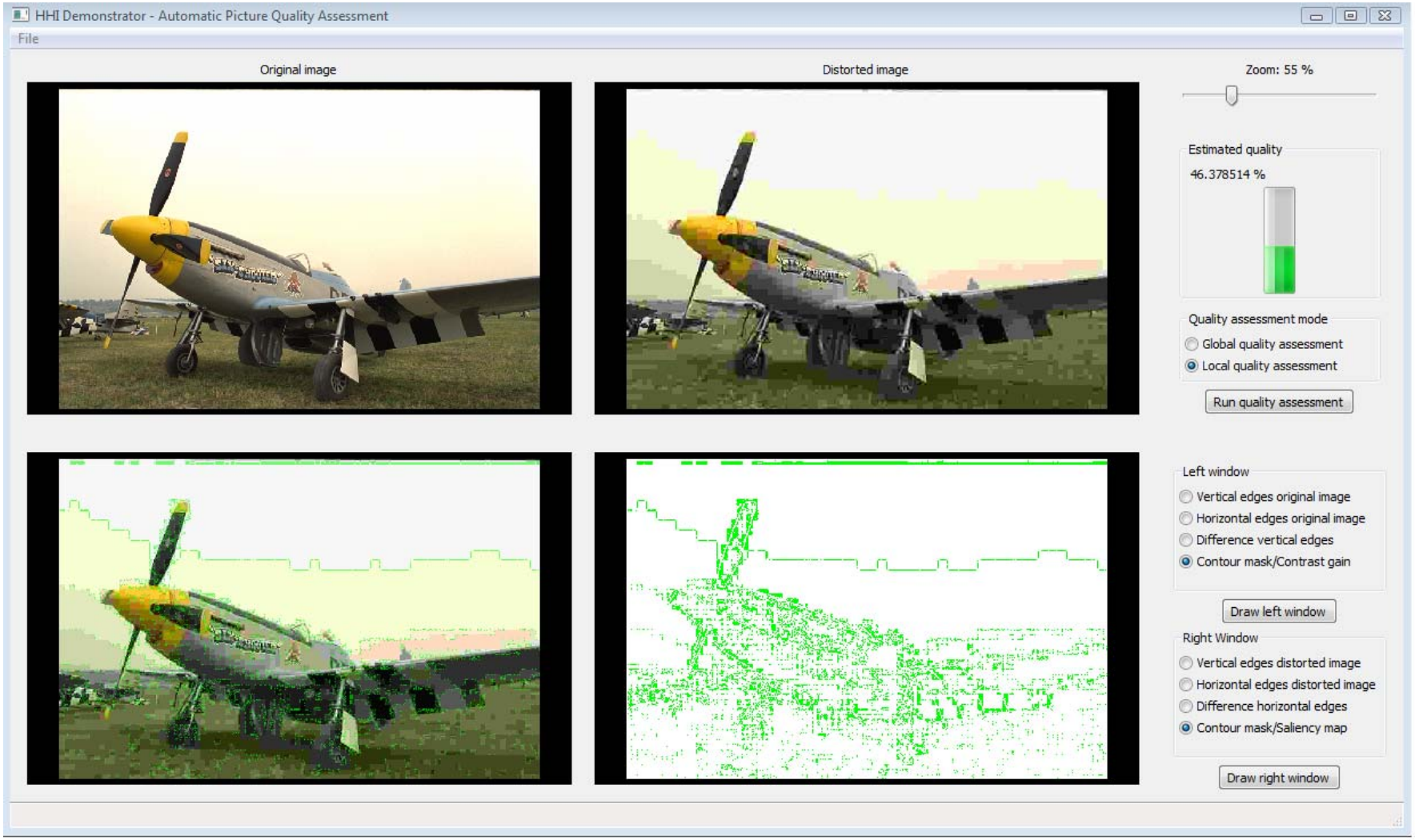

Application Scenario 1: Quality Assurance in CONTENTUS

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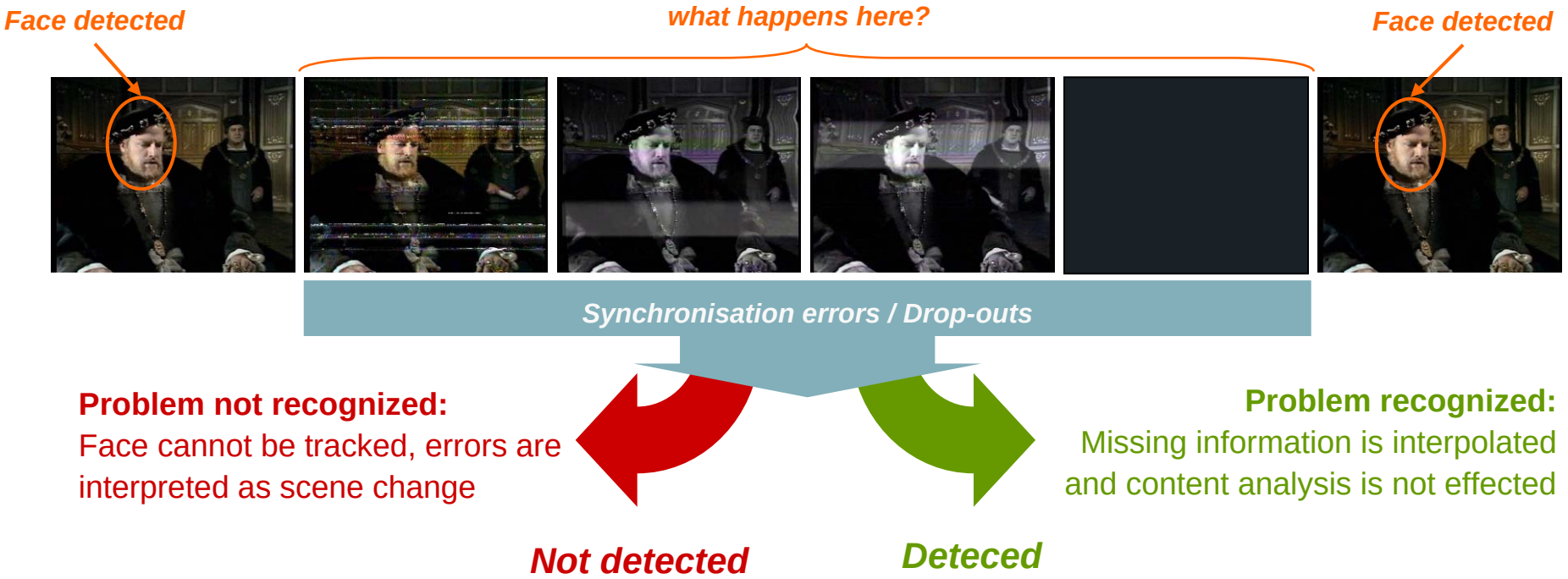
- „Quality survey“ of video archives is essentiell → value of content
  - Example: Implications of quality problems



Quality Assurance by automatic quality analysis

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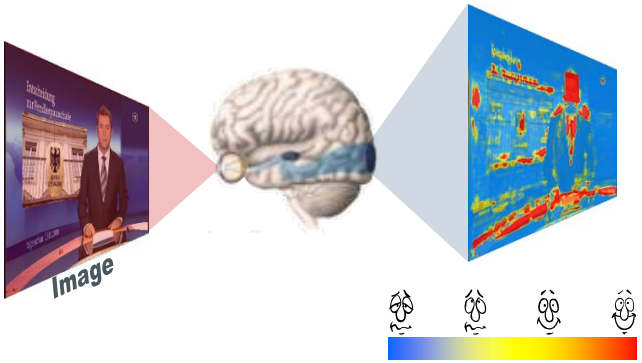
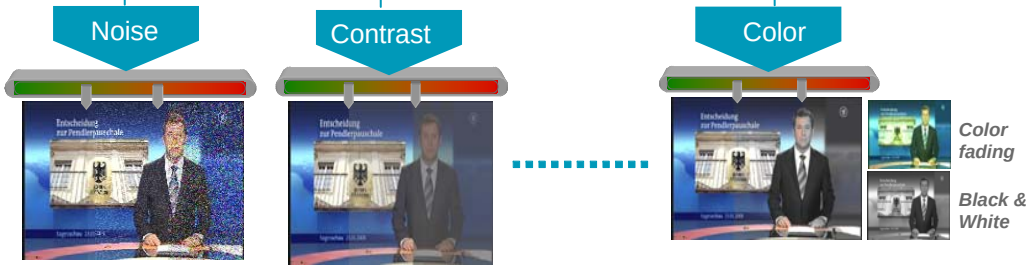
» Quality features and models of human visual system

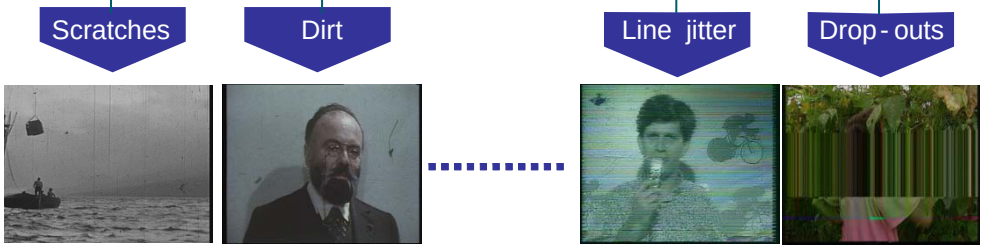
Human visual models



Perceptual no-reference quality metrics



Specific image artifacts



Features of Detection and Restauration Framework

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- Detection, localisation and classification of quality properties
  - information as standardized metadata
  - robust automatic detection
  - high data throuput by efficient algorithms
- Metadaten allow immediate or later restauration
  - new „region filling“ and wavelet based reconstruction preserving textures
- Scalable solutions for different content
  - film and video
  - with low or high compression factor
  - high or low resolution
- Additional information for searching → search for quality

Restauration result

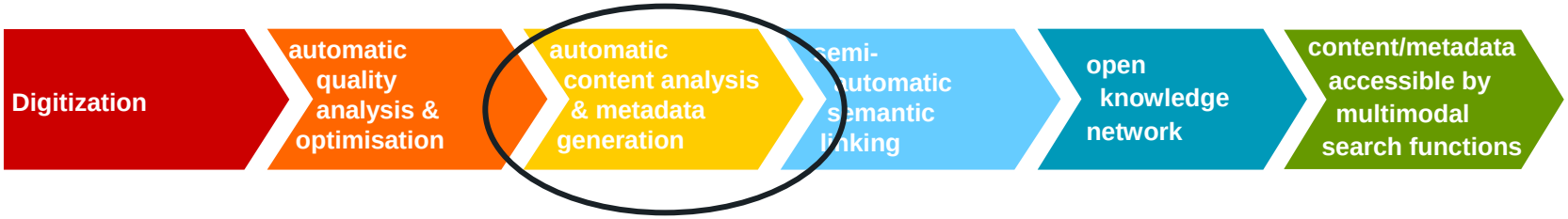
» Very robust in comparison to existing mehods (example: scratch removal)

Web Video

CONTENTUS solution

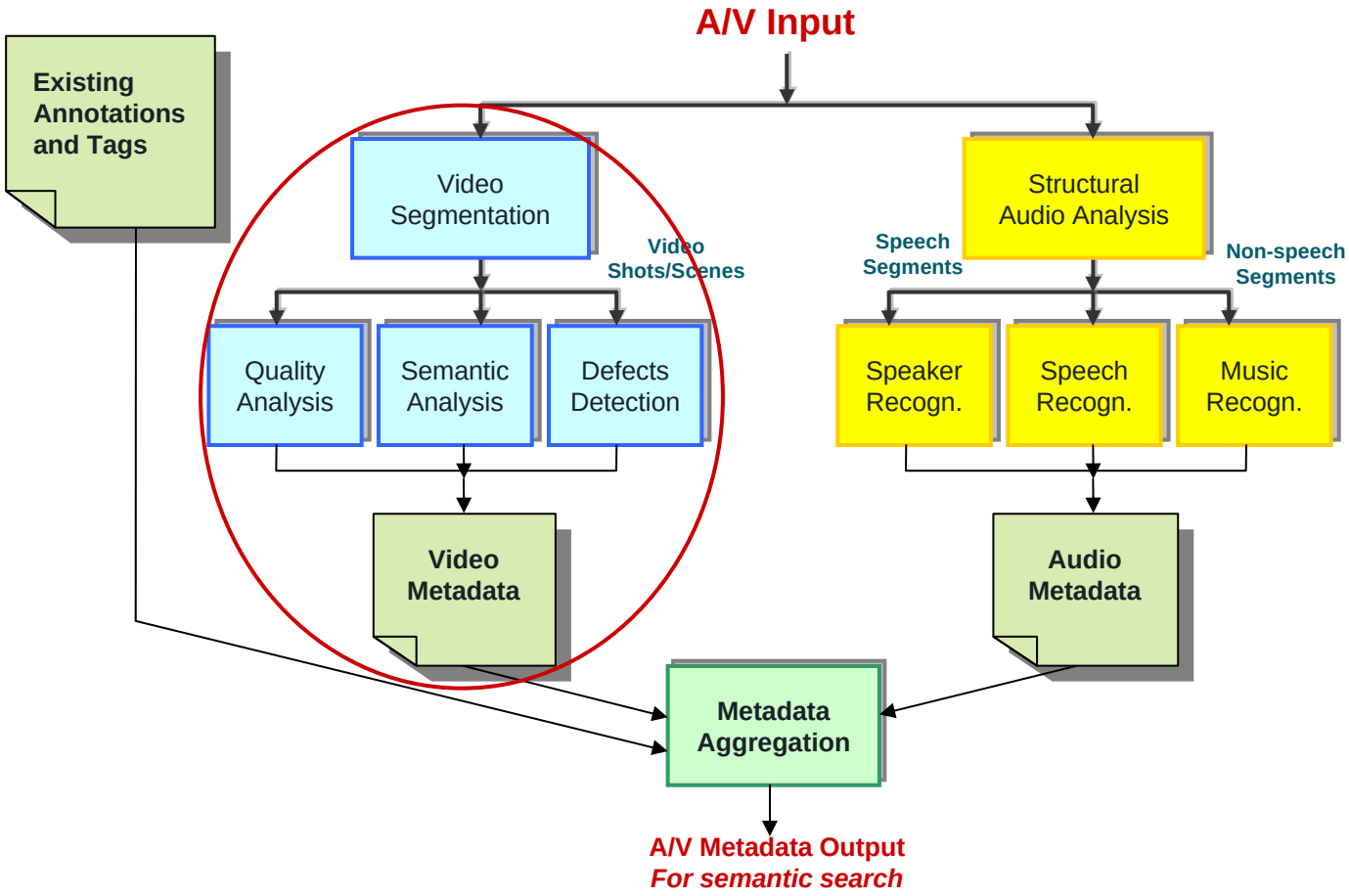
Presented at IBC 2009

Application Scenaro 2: Video content analysis

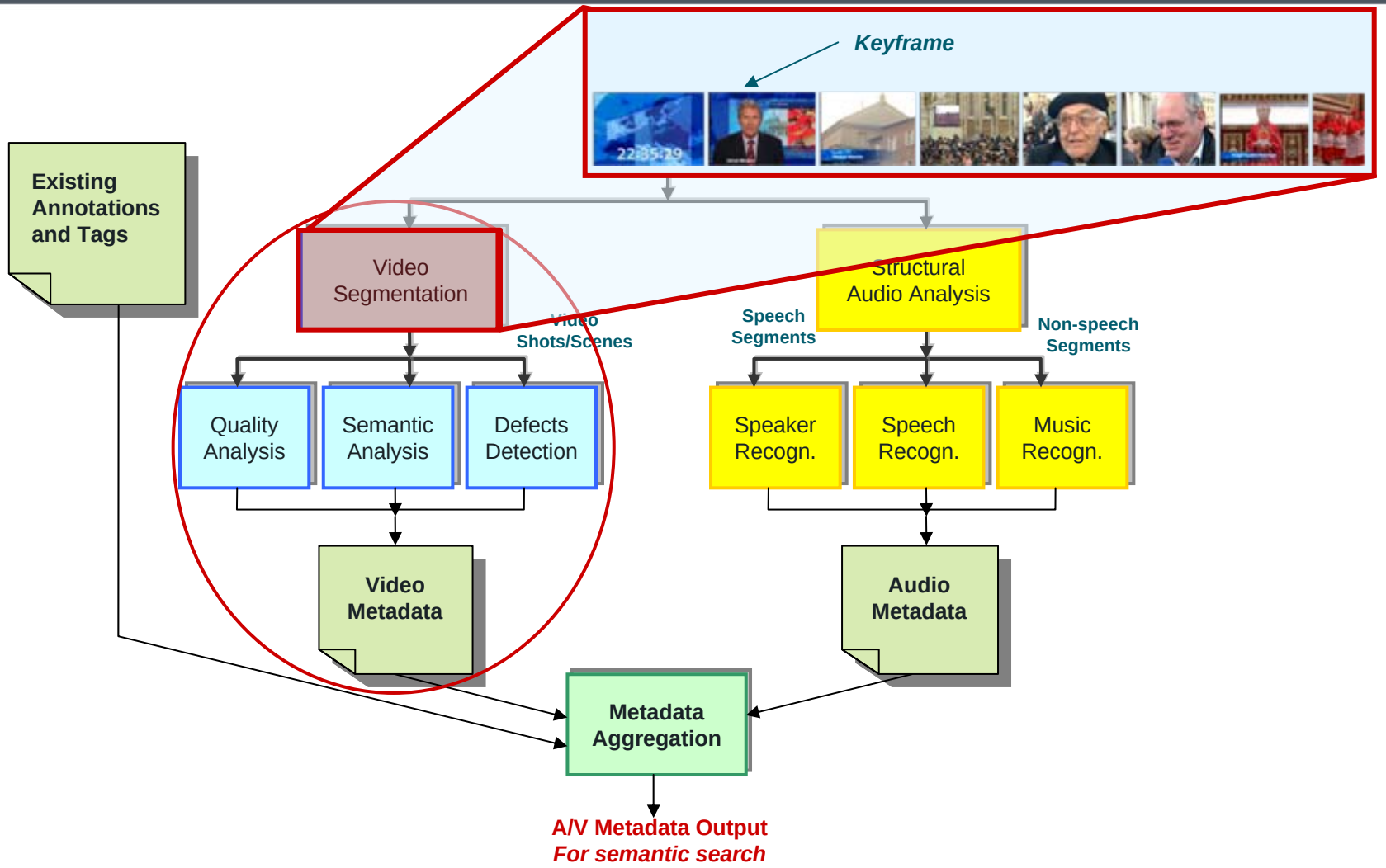


- **Challenges:**
- Volume of data
  - 5,9 Mio. film reels / 6,2 Mio. video tapes in Europe → difficult access
  - E.g. BR has digitized 26 km shelves with 700.000 tapes
- Throughput
  - Broadcasters archive up to 140 hours per day
  - Metadata are manually added → 4 hours of work for 1 hour of video
- Semantic information
  - Today‘s metadata no not allow semantic search
  - Semantic Analysis of video content is still in its infancy

Video content analysis



Video content analysis



Video content analysis

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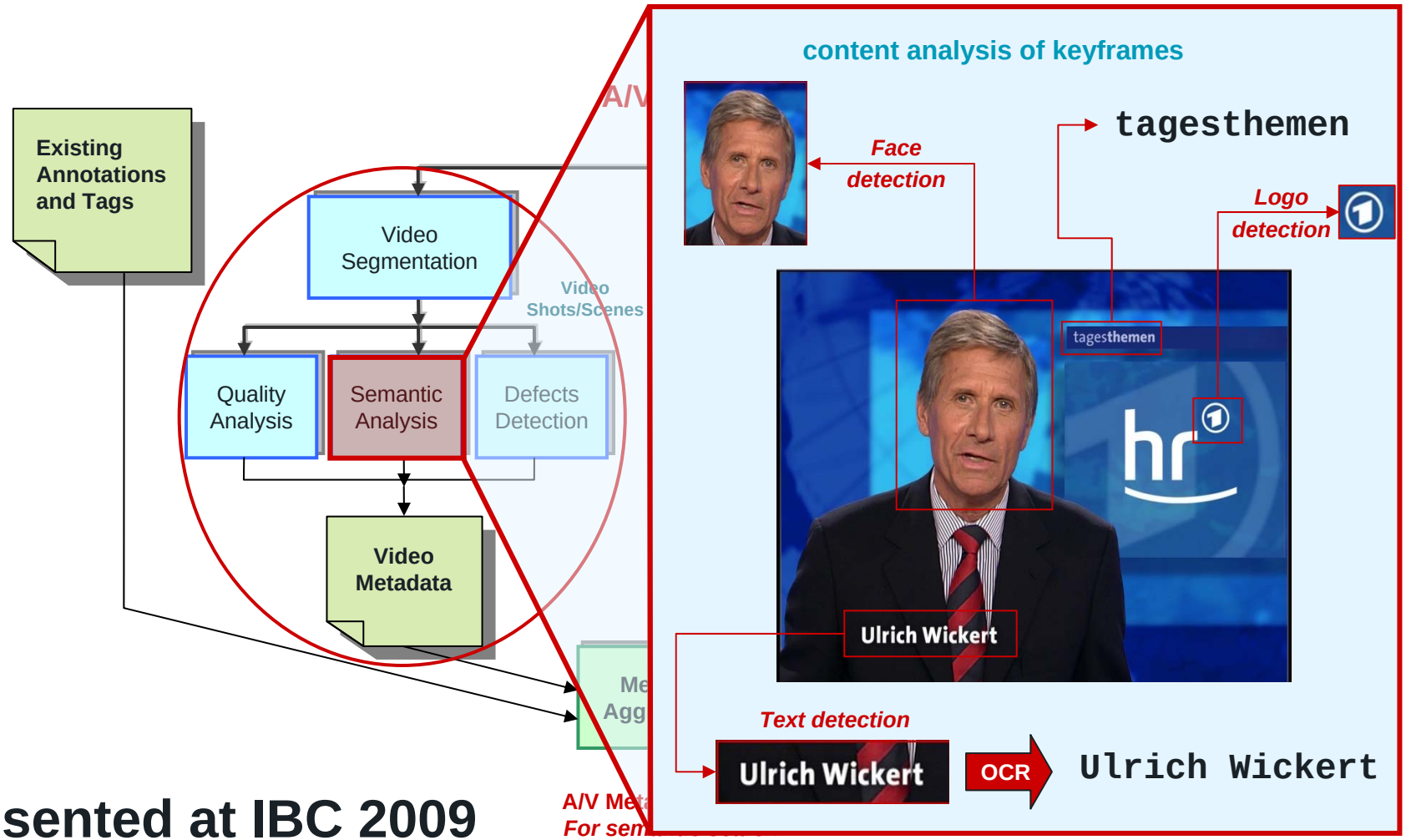

Presented at IBC 2009

Semantic video content analysis

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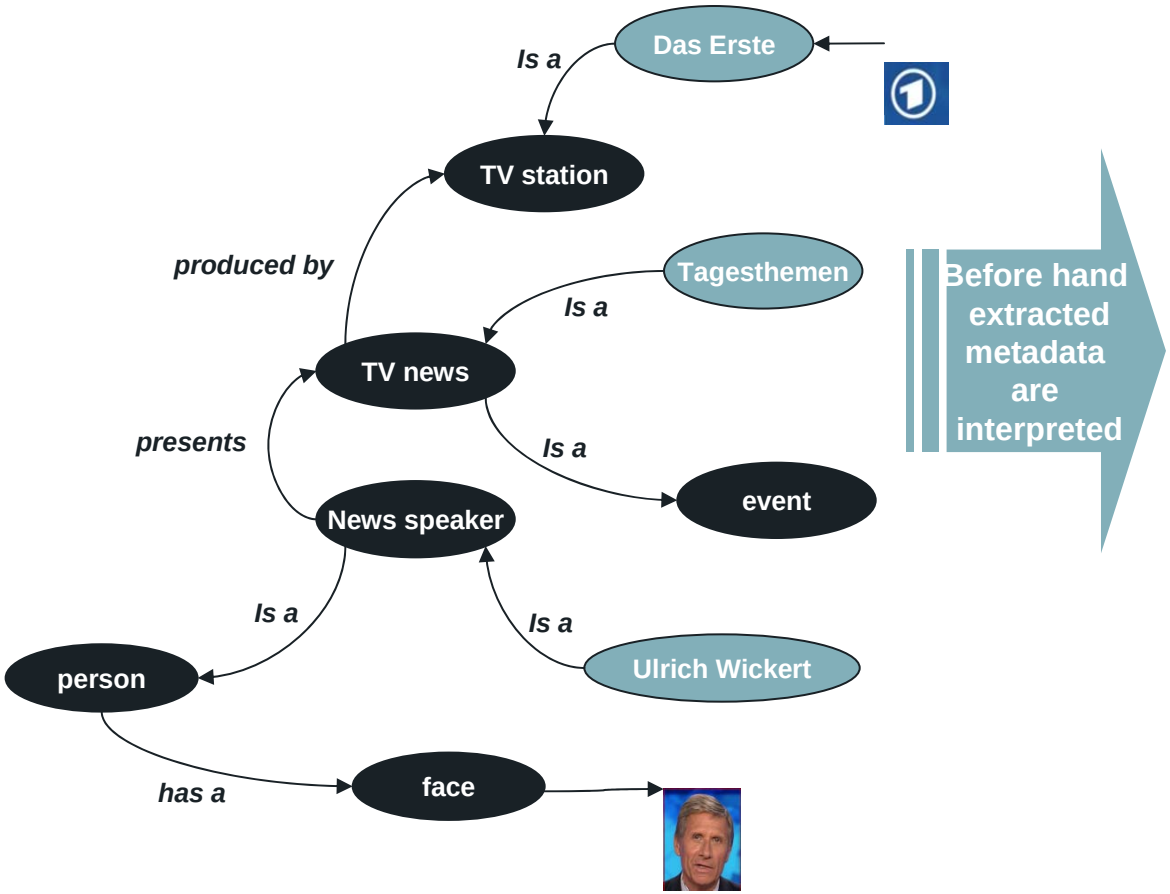
» Usage of knowledge data bases (ontologies) for image interpretation



Before hand extracted metadata are interpreted

Germany's news "Tagesthemen" of „das Erste" presented by Ulrich Wickert

Semantic video content analysis

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» Automatic structuring of a video segment

Interview with the pope's brother

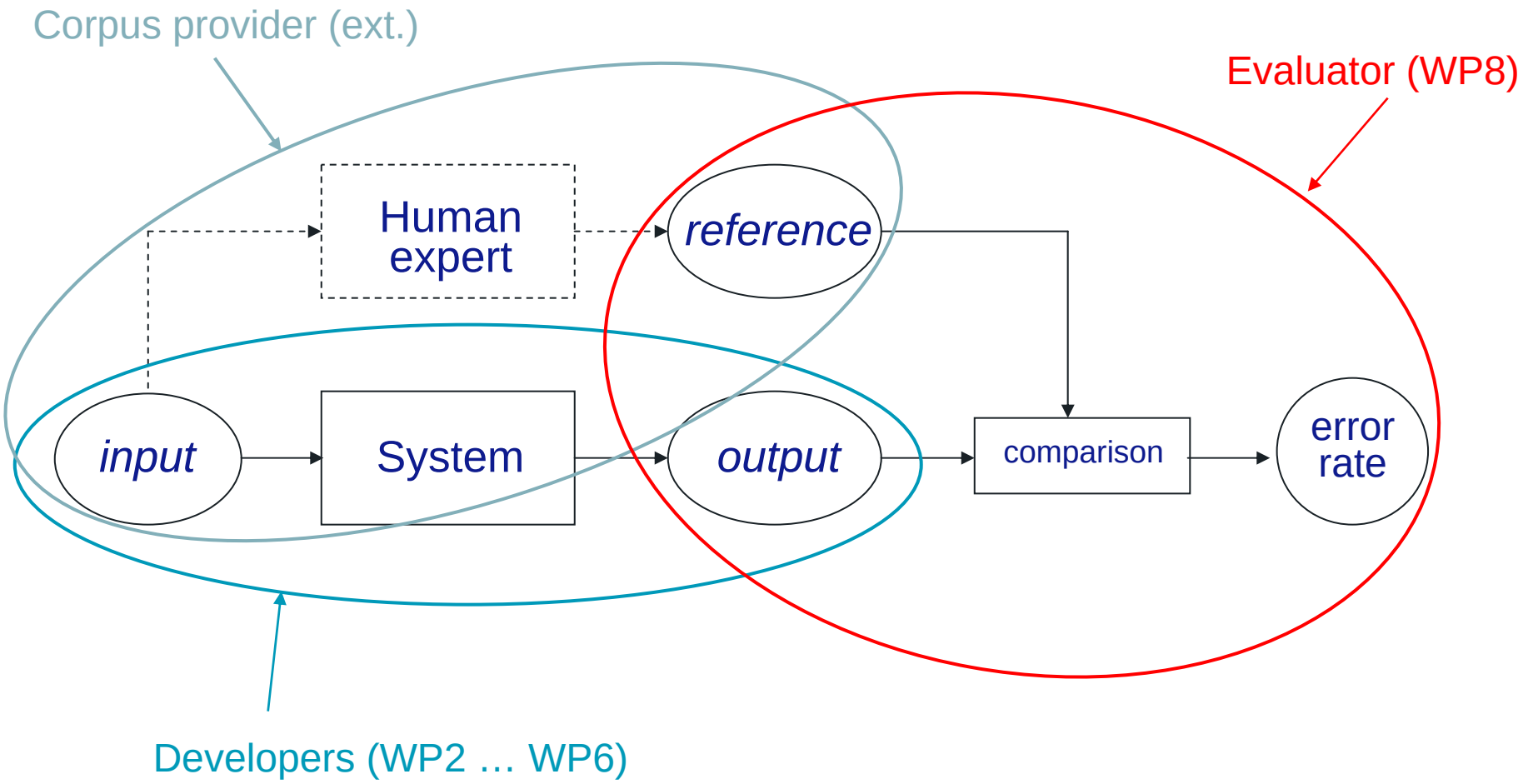
Presented at IBC 2009

Approach for video content analysis

Summary of approaches for video content analysis:

- Automatic generation of semantic video metadata
- Generic, open and extendable metadata format
- New metadata by combination of existing components for analysis
- Iterative enrichment and extension of metadata
- Efficient usage of human resources for indexing
- Development of ontologies and data models
- Distributed system architecture to accelerate data throughput
- Dedicated „content repository“

Evaluation - Organisation and Roles



Evaluation of Core Technologies

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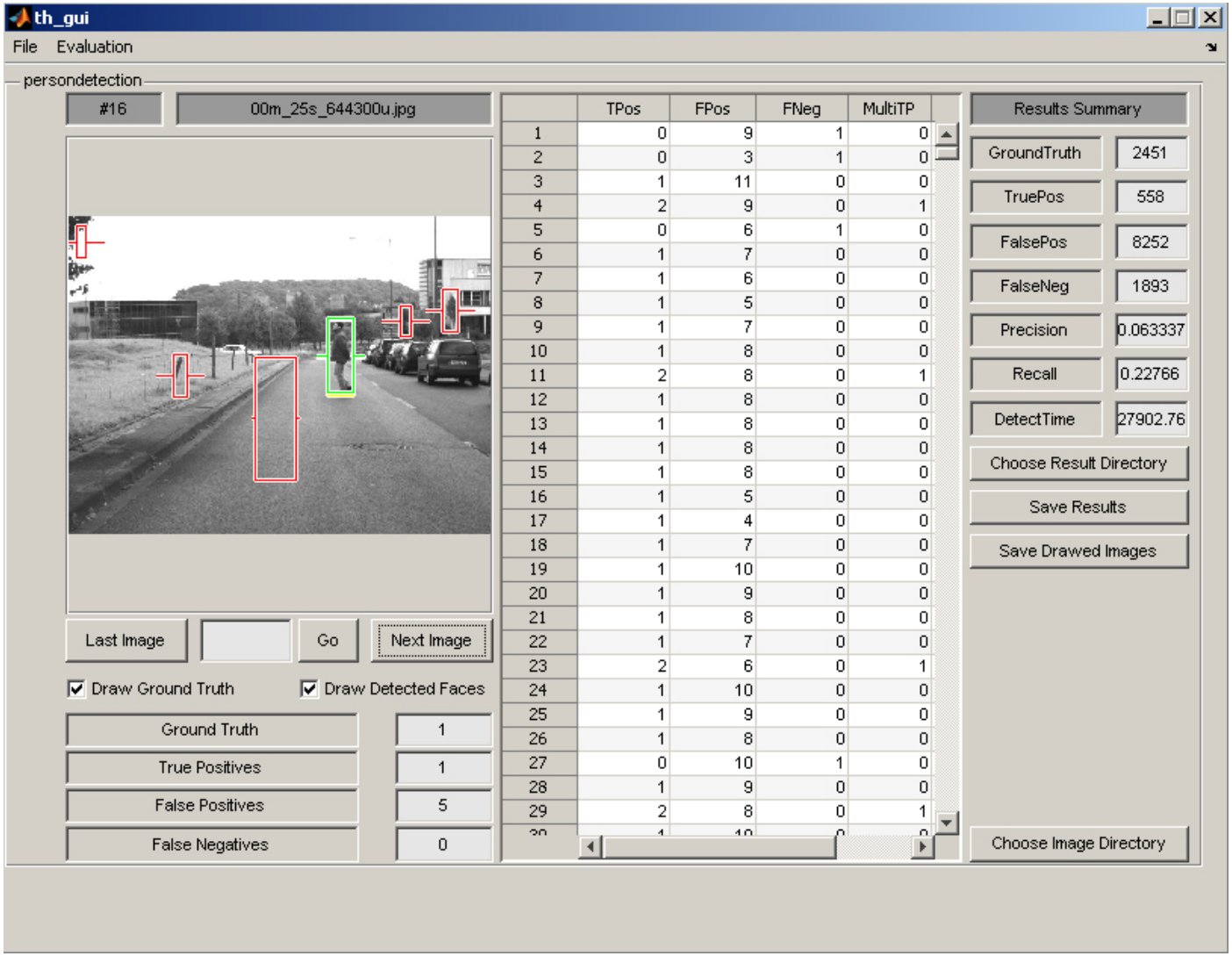
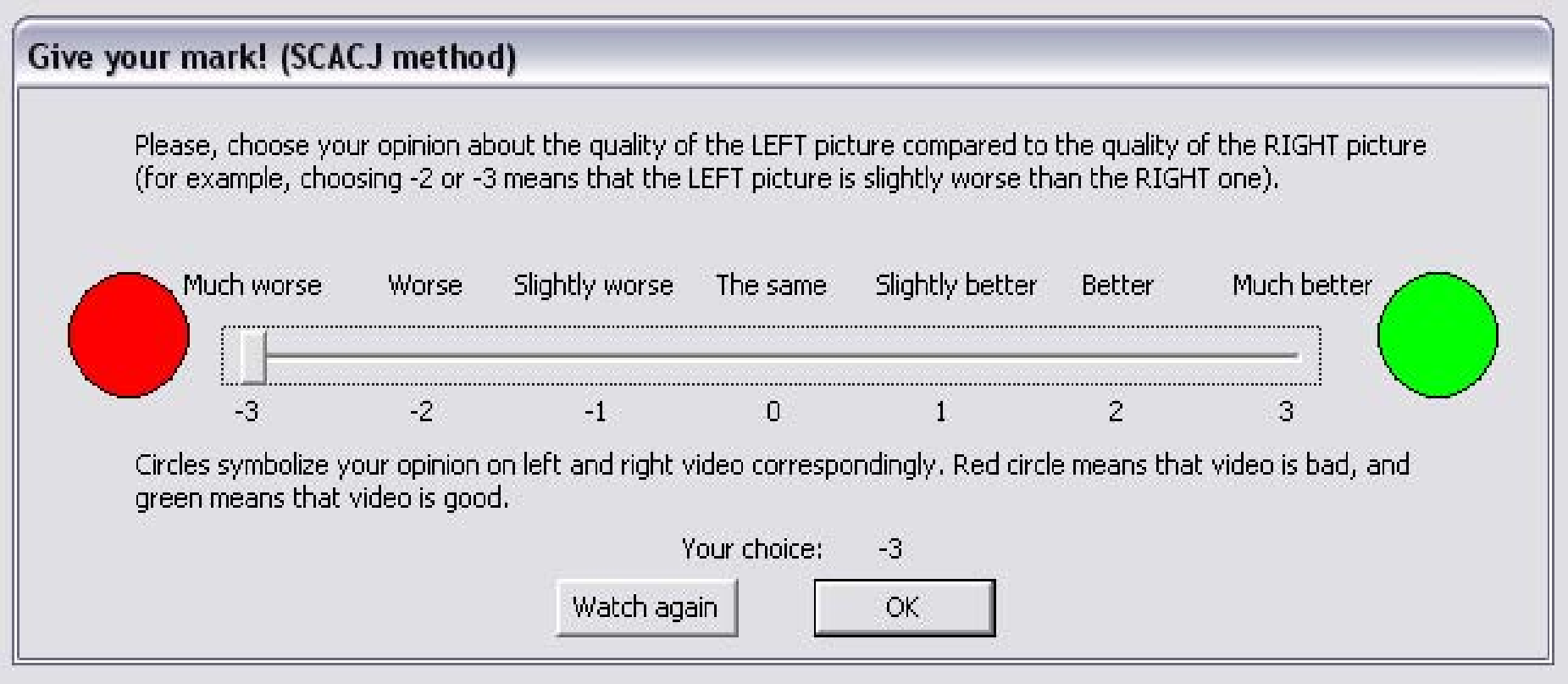
- Evaluation of CTC technologies is an ongoing task in THESEUS
- Different methods according to technologies under test are used or have been especially developed:
  - Existing corpora
  - Especially created corpora
  - Hand annotation of corpora
  - Usage of reference methods
  - Creation of methodologies and test tools
  - Usage of existing and design of new metrics
  - Subjective testing
  - Etc.
- Participation in international challenges such as ImageCLEF, TRECVID or PascalVOC

Examples for tools



Test tool for image segmentation

Examples for tools



Test tool for quality assessment

Will be presented in more detail by IDMT colleagues

Summary

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- THESEUS is a German joint research program dedicated to the development of “semantic technologies to enable the Internet of Services”
- There are 6 Use Cases developing application scenarios and a Core Technology Cluster (CTC) developing generic technologies, which will be used in the Use Cases
- Image and video processing technologies play an important role in the CTC
- Two application scenarios
  - Digitization with automatic quality assessment
  - Application scenario: Automatic content analysis & metadata

  have been presented in more detail
- Evaluation of Core Technologies plays an important role in THESEUS
- Participation in international challenges such as ImageCLEF is of utmost importance for this evaluation process.

The End

THESEUS
Forschungsprogramm für eine neue internetbasierte Wissensinfrastruktur

Thank you

We put science into action

http://theseus-programm.de/

http://ip.hhi.de