Università degli Studi di Trieste

Corso di Laurea Magistrale in
INGEGNERIA CLINICA

BIOIMAGE DATABANKS

Corso di Informatica Medica

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NEEDS AND TOOLS

- **Needs** →
  - The Visual knowledge is fundamental in medicine → bioimage interpretation requires a good set of examples (reliable visualization)
  - Comparing different types of images of the same structure in the same condition helps validating the technique and the instrumentation
- **Tools** →
  - Information and communications technologies are available and have then potential to manage big archives

→ **WE EXPECT THAT GOOD BIOIMAGE ARCHIVES EXIST AND ARE AVAILABLE TO THE PUBLIC**

THE VALUE OF VISUAL KNOWLEDGE: EXAMPLE

http://wise-md.med.nyu.edu/wmd_demo.jsp

LIMITS

- The expected availability is not met
- Bioimage instrumentation rapidly evolves
- Bioimage technologies are still high-cost technologies
- Bioimages are represented through the DICOM standard but there are still proprietary features
- Bioimage databanks are still related to business interests →
  - ✓They can prove the efficacy/capacity of a certain commercial system
  - ✓Can be part of the system package sold

VISUALIZATION TOOLS

- **Software packages** are provided to enhance the interpretation capacity
- They include analysis tools that can provide
  - **OBJECTIVE enhancement:** all users agree that the visualization improved once the tool is applied (noise reduction)
  - **SUBJECTIVE enhancement:** the user decides what tool to apply to improve the image visualization (personalized)

The final choice depends on the aims of the expected users

ATTRIBUTES OF A BIOIMAGE DATABANK

TARGETS

- Aims of the biomage databank
- Medical specialty
- Number of cases and their selection process
- What needs are answered by the databank

PREPARATIONS

- Any preparation of the selected cases

METHODOLOGY

- What bioimage technique
- Parameters of the instrumentation
- Contrast medium

ACQUISITION

- Acquisition chain and its parameters
- Sensors

ATTRIBUTES OF A BIOIMAGE DATABANK

FILE ORGANIZATION

- Originary/Raw files
- Processed files (e.g., compression)
- File system

MEMORY SIZE

- Occupied memory by the files

VISUALIZATION RECOMMENDATIONS

- Suggested resolution
- Suggested methodology

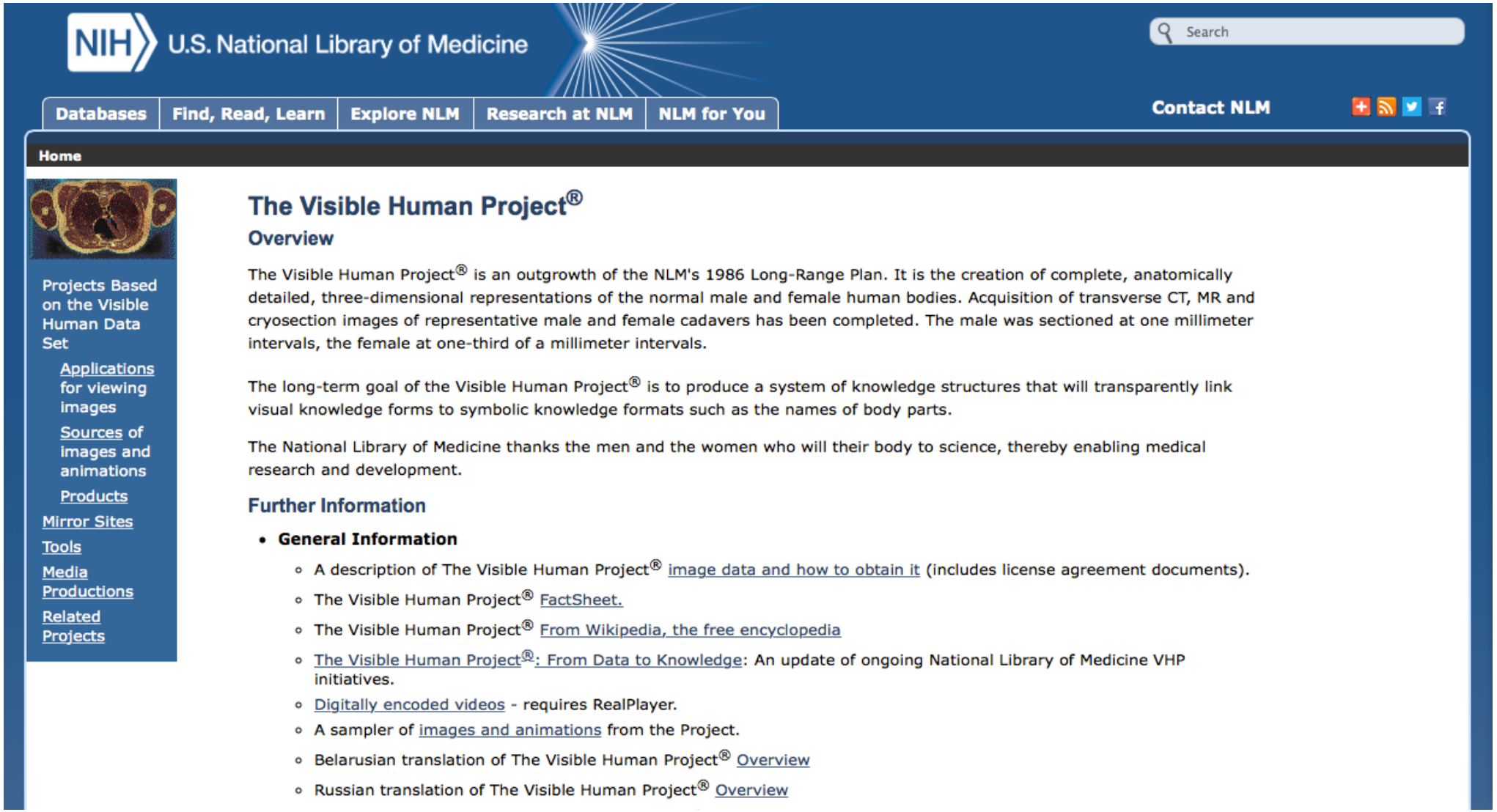
TRAINING AND MANUALS

- Availability
- Cost (if applicable)

EXAMPLES

- DIGITAL ANATOMY
  - Visible Human Dataset
  - Digitalization of paper-based atlases and 3D anatomy visualization
  - Bioimage querying
- CLINICAL BIOIMAGE DATABANKS
- PICTURE ARCHIVING AND COMMUNICATION SYSTEMS (PACS)

Visible Human Dataset



http://www.nlm.nih.gov/research/visible/visible_human.html

Visible Human Dataset (VHD)

- Anatomical 3D atlas composed by pictures of the human body
- 1990s
- Digitalized pictures (and digital pictures, in the next editions) of sections of a frozen human body
- Main problems:
  - Make the databank available to the public
  - Freeze the human body
  - Influence of the volume changes due to freezing on relative volumes
  - Mechanical alignement of the fresa
  - Colour enhancement

VHD features: US experience

Nome	Tipo di Immagine	Intervallo di sezionamento/ campionamento [mm]	Numero di immagini	Dimensioni [pixel^2]	Profondità [bit]	Dimensioni [GB]	Disponibile dal
Visible Human Project Male Dataset [Spitzer et al., 1996], [NLM, 1996]	MR images	4.0	1028	256 x 256	12; liv. grigio	16	Novembre 1994
	CT images	1.0	1871	512 x 512	12; liv. grigio		
	Anatomical images (Full Color)	1.0	1871	2048 x 1216	24; colori		
	Anatomical images (Higher resolution)	1.0	1871	4096 x 2700	24; colori	60	Agosto 2000
Visible Human Project Female Dataset [NLM, 1996]	MR images	4.0-5.0	1043	256 x 256	12; liv. grigio	40	Novembre 1995
	CT images	1.0	1734	512 x 512	12; liv. grigio		
	Anatomical images (Full Color)	0.33	5189	2048 x 1216	24; colori		

VHD features: other experiences

Nome	Tipo di immagine	Intervallo di sezionamento/ campionamento [mm]	Numero di immagini	Dimensioni [pixel²]	Profondità [bit]	Dimensioni [GB]	Disponibile dal
Chinese Visible Human Male Dataset [Zhang et al., 2003]	MR images	1.5 - 3.0	*	512x512	8; liv. grigio	90.65	Ottobre 2002
	CT images	1.0	*	512x512	8; liv. grigio		
	Anatomical images	0.50 testa e collo 1.0 resto del corpo	2518	3072x2048	24; colori		
Chinese Visible Human Female Dataset [Zhang et al., 2003]	MR images	1.5 - 3.0	*	512x512	8; liv. grigio	131	Febbraio 2003
	CT images	1.0	*	512x512	8; liv. grigio		
	Anatomical images	0.25 testa 0.50 resto del corpo	3640	3072x2048	24 colori		
Visible Korean Human (Male) [Park et al., 2005]	MR images	1.0	1718	505x276	8; liv. grigio	197.5	Marzo 2001
	CT images	1.0	1718	505x276	8; liv. grigio		
	Anatomical images	0.20	8590	3040x2008	24; colori		
	Segmented images	0.20	8590	3040x2008	8; colori		

ATTRIBUTES OF THE VHD: IDENTIFICATION

Name
- Visible Human Dataset

Property
- National Institutes of Health; U.S. National Library of Medicine (NLM), 8600 Rockville Pike, Bethesda, MD 20894

Date
- First editions: 1993 (male dataset), 1994 (female dataset)
- Updates: 2000 (high-resolution images)

Access
- Via ftp: NLM website (main) and 3 mirror sites (Milan, Italy (now closed); Singapore; Tokyo, Japan)
- Tapes: exabyte 8mm or DAT 4mm but require tape readers.

ATTRIBUTES OF THE VHD: TARGET

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Aims	• Digital healthy human (male and female) anatomy library
Medical specialty	• Anatomy, healthy subjects (educational aim)
Number of cases	• 2 cases
Selection criteria	• Protocol sestablished by three “State Anatomical Boards” (Virginia, Maryland, Colorado)

ATTRIBUTES OF THE VHD: PREPARATION

Anaesthesia:

- Cause of Death <death injection, arresto cardiocircolatorio>

Freezing:

- First step: –7°C
- Second step: –70°C

Mechanical precision:

- Cutting tool: 14 inches disk, 20 diamonds teeth
- 0.1 mm resolution (non strappato)
- 1 mm step for the male dataset
- 0.33 step for the female dataset

ATTRIBUTES OF THE VHD: METHODOLOGY

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Fotografie	Radiografie	TAC	MR	PET	SPECT	ECO
Digitali a colori (RGB). CCD: raw 2048x2048x14 bpp; Dataset Maschile Dimensione del pixel 0.33mm,0.33mm, intervallo di separazione: 1mm Dataset Femminile Dimensione del pixel 0.33mm per 0.33mm, intervallo di separazione: 0.33mm	*15 radiografie di prova (solo per il dataset maschile)*	*Scala di grigio (12 bit significativi) Per ciascuna immagine è disponibile un file intestazione contenente tutti i parametri di esecuzione. (Dataset Maschile (fresh, frozen) e Dataset Femminile)*	*Ogni sezione acquisita con le modalità (t1, t2, pd) Per ciascuna immagine è disponibile un file intestazione contenente tutti i parametri esecuzione. (Dataset Maschile e Dataset Femminile)*			
Su pellicola da 70 mm colore RGB. Dimensione del pixel 0.144mm per 0.144mm, intervallo di separazione:1mm						

ATTRIBUTES OF THE VHD: METHODOLOGY

Bioimage organization

- **Single static images**
- **Multiple images**
  - Sequences
    - Time sequences
    - Direction sequences: vertical direction (CT scan and pictires), axial direction (MRI neck and head), coronal direction (MRI all the other body)
  - Sampling
    - regular sampling
    - selective sampling
    - exaustive sampling
    - a priori limited sampling
- **Movies**

ATTRIBUTES OF THE VHD: ACQUISITION

Resolution: digitized pictures

- x: 2048 pixels; y: 2048 pixels ; z: pixels
- RGB with 14 bit grey level resolution for each channel (Red, Green, Blue)

Resolution: analogical pictures

- 35 mm and 70 mm film

Resolution: CT and MRI

- CT scan: 12 bits gray scale; 512 x 512 x 16 bit per pixel
- MRI: 12 bits gray scale; 256 x 256 x 16 bit per pixel; T1, T2 and PD sequences

ATTRIBUTES OF THE VHD: FILE ORGANIZATION

Original files: Not available (big size)

Compressed files: Available on the ftp site

File Systems:

MALE:

70mm <Fullbody>

Fullcolor < Fullbody; Abdomen; Head; Legs; Pelvis; Thighs; Thorax>

Radiological <frozenCT; frozenCTHeaders; MRI; MRIHeaders; NormalCT; NormalCTHeaders; ScoutCT; xray14; xray8>

FEMALE:

Fullcolor < Fullbody; Abdomen; Head; Legs; Pelvis; Thighs; Thorax>

Radiological <MRI; MRIHeaders; NormalCT; NormalCTHeaders >

ATTRIBUTES OF THE VHD: MEMORY SIZE

Total size

- 15 GB Male dataset (1994)
- 40 GB Female dataset (1996)
- 60 GB high-resolution images of the male dataset (2000)

Sections

- To calculate the size, sum all the files pertaining to a section

ATTRIBUTES OF THE VHD: VISUALIZATION

Display hardware

- x: 2048 pixels;
- y: 2048 pixels ;
- RGB with 14 bit grey level resolution for each channel (Red, Green, Blue)
- *Standard PC displays are able to reproduce the images*

Visualization software

- Photoshop
- JPEG
- *For grey scale images, set "Image-> Adjust -> Auto Levels", otherwise the image is displayed as fully black*

ATTRIBUTES OF THE VHD: TRAINING AND MANUALS

Available at:

NLM website →
http://www.nlm.nih.gov/research/visible/visible_human.html

WARNING:

The VHD-Milano Mirror Site→ http://vhd-mms.cilea.it/ no longer exists

The use of the VHD

http://www.nlm.nih.gov/research/visible/applications.html

The use of the VHD: examples

- http://vhp.med.umich.edu/movies2.html
- http://vhp.med.umich.edu/VH_JAVA2b.mov
- http://vhp.med.umich.edu/ew4.mov

Digital anatomy: image database query (1/8)

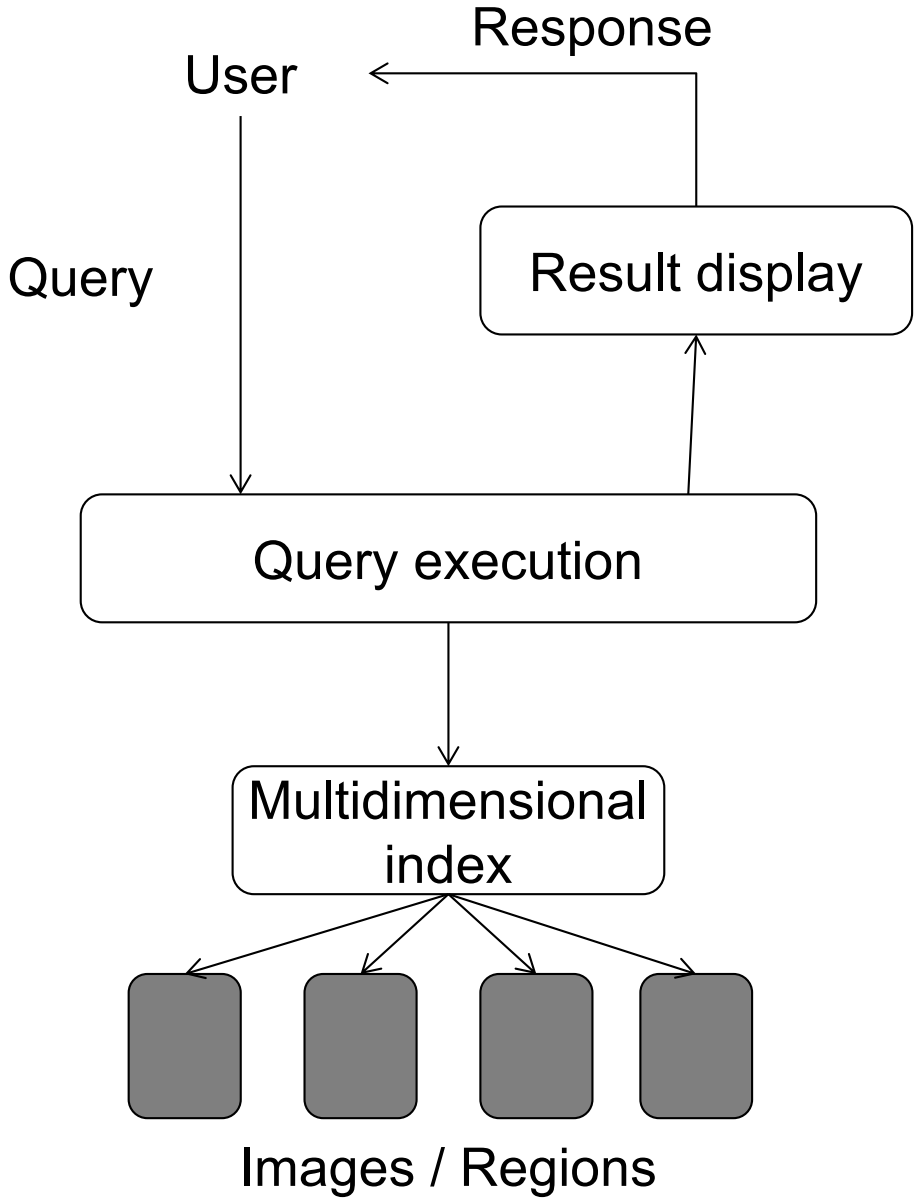
- Trade off between:
  - Simple queries (image number N)
  - Difficult queries (images that show a specific body part)
- Content Based Image Retrieval (CBIR)
- There is the need of specific DBMS (usually object oriented) to define the methods related to the "image" class

Digital anatomy: image database query (2/8)

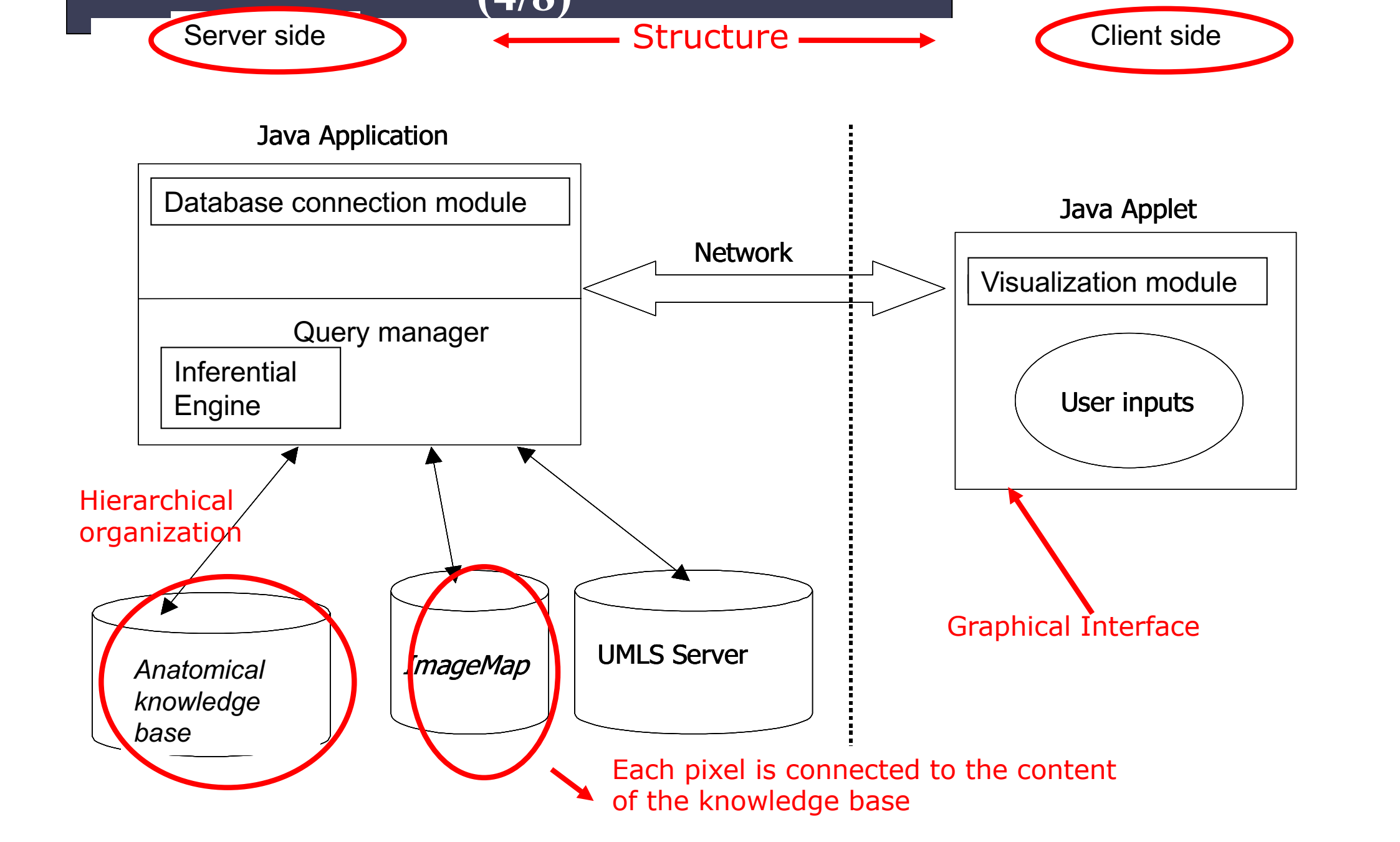
- **Image editing methods**:
  - Open and display different image types
  - Rotation, zoom, colour inversion, contrast management
- **Feature extraction methods**:
  - Retrieve information on the image features (colour, textire, shapes)
  - Example: colour histogram
- **Region extraction methods**:
  - Group the pixels belonging to a region

Digital anatomy: image database query (3/8)

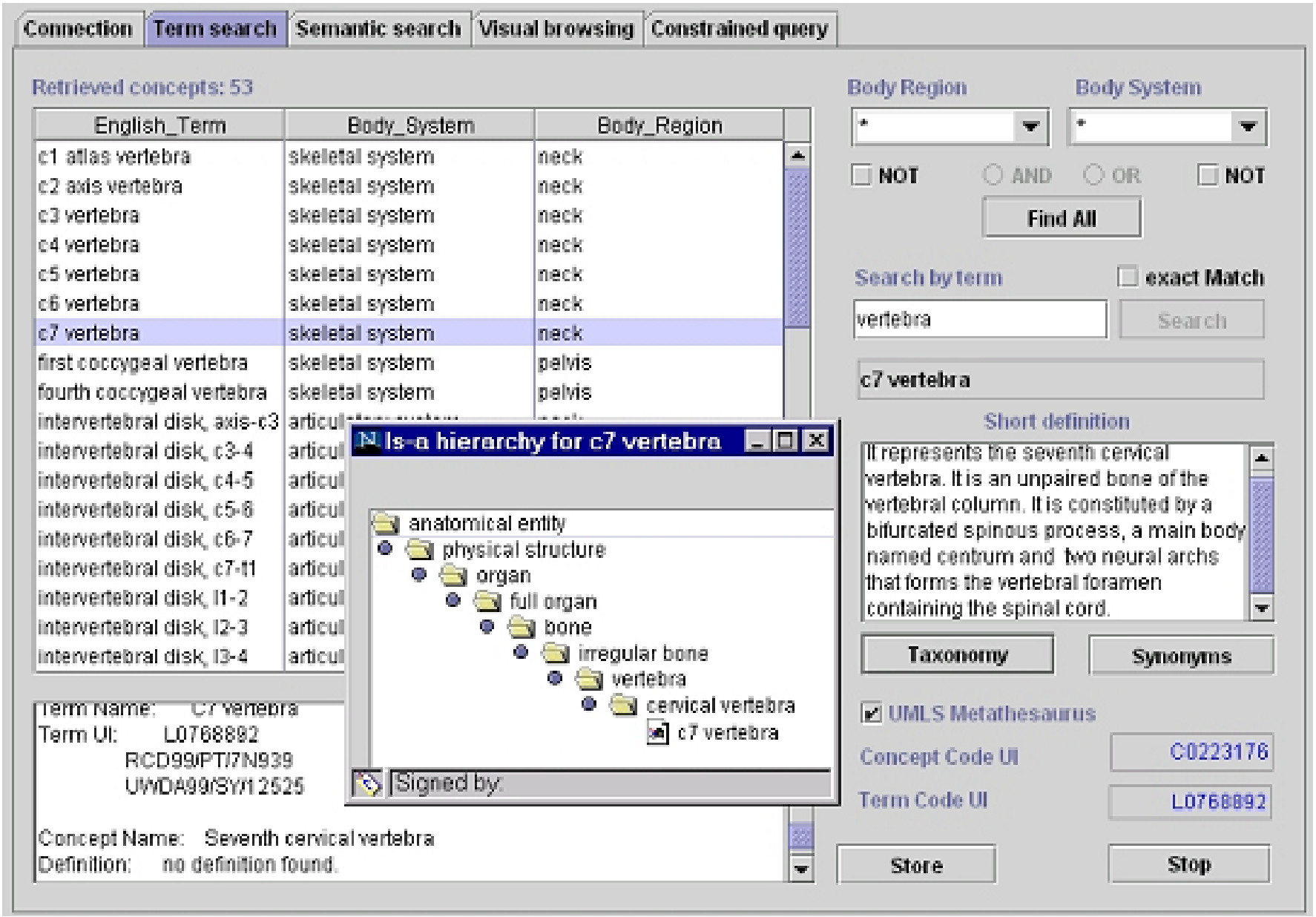
Query workflow



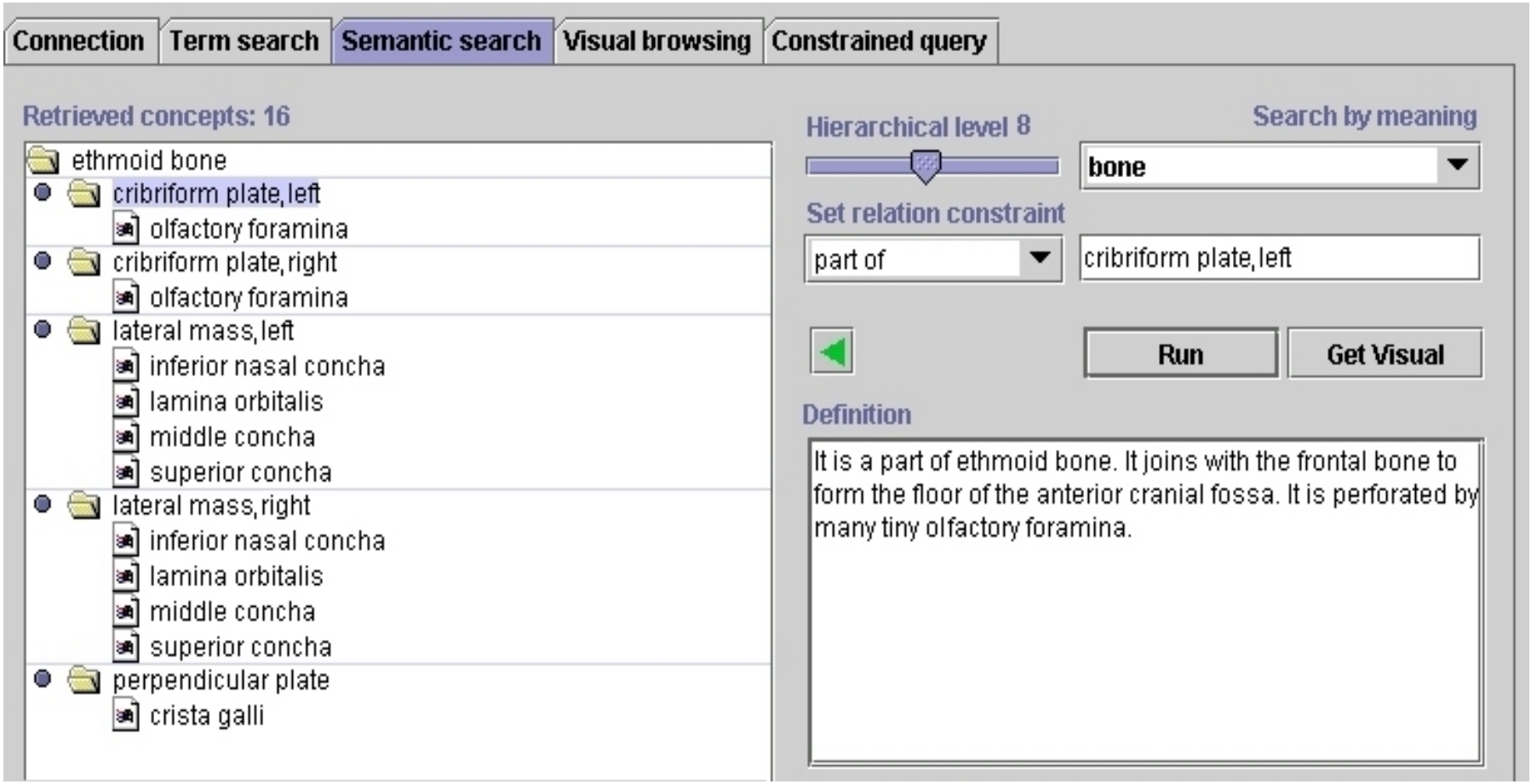
Digital anatomy: image database query (4/8)



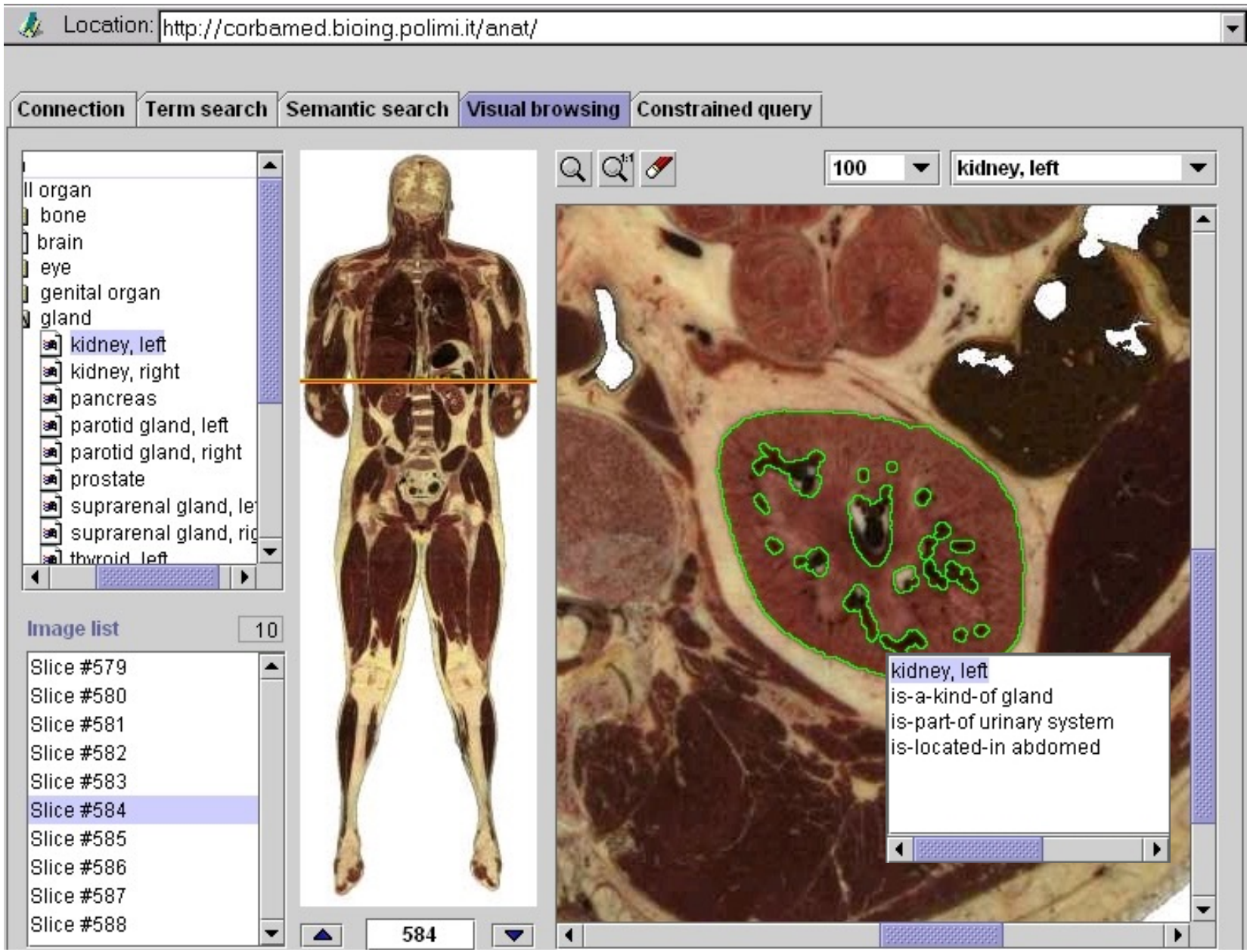
Digital anatomy: image database query (5/8)



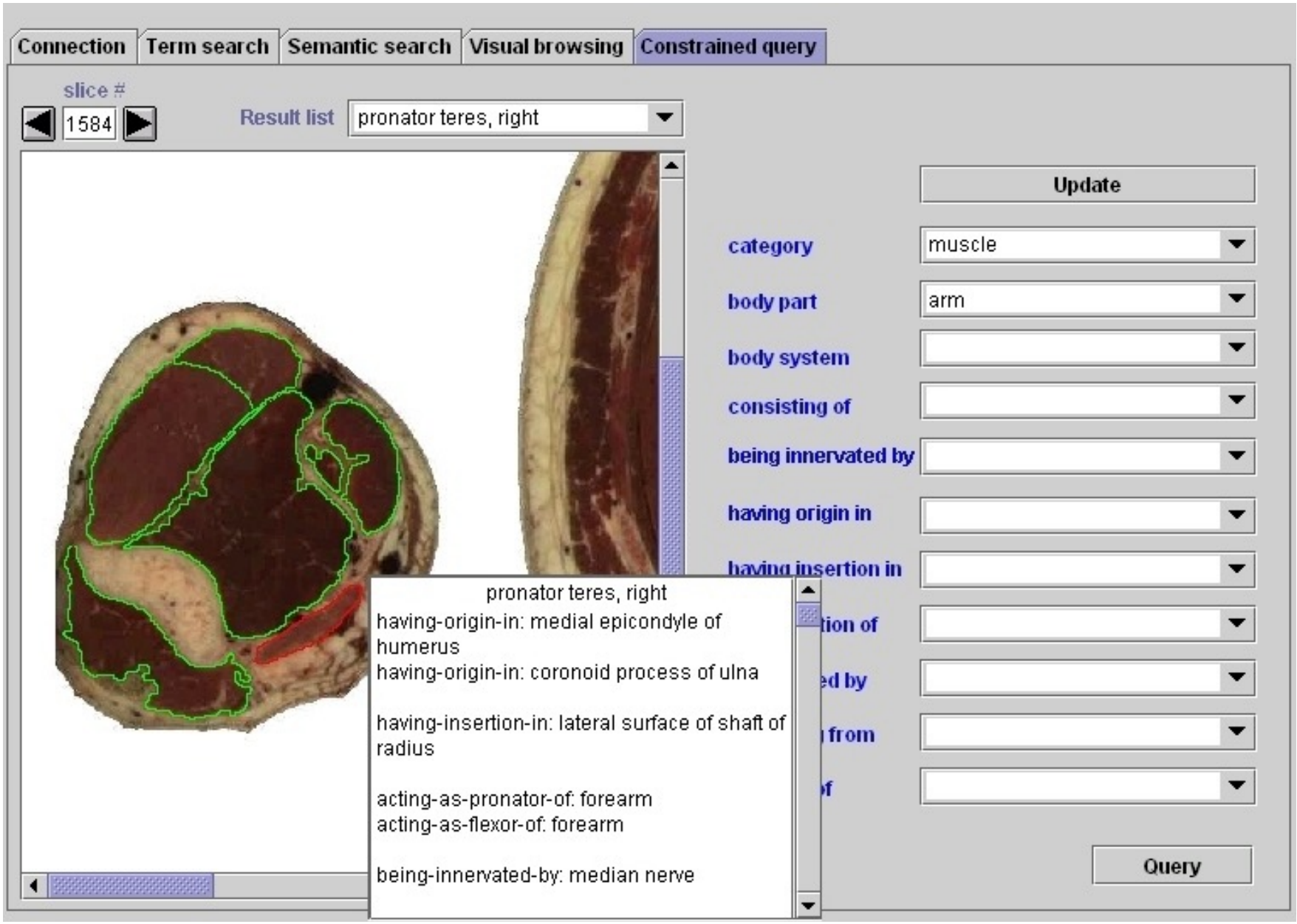
Digital anatomy: image database query (6/8)



Digital anatomy: image database query (7/8)



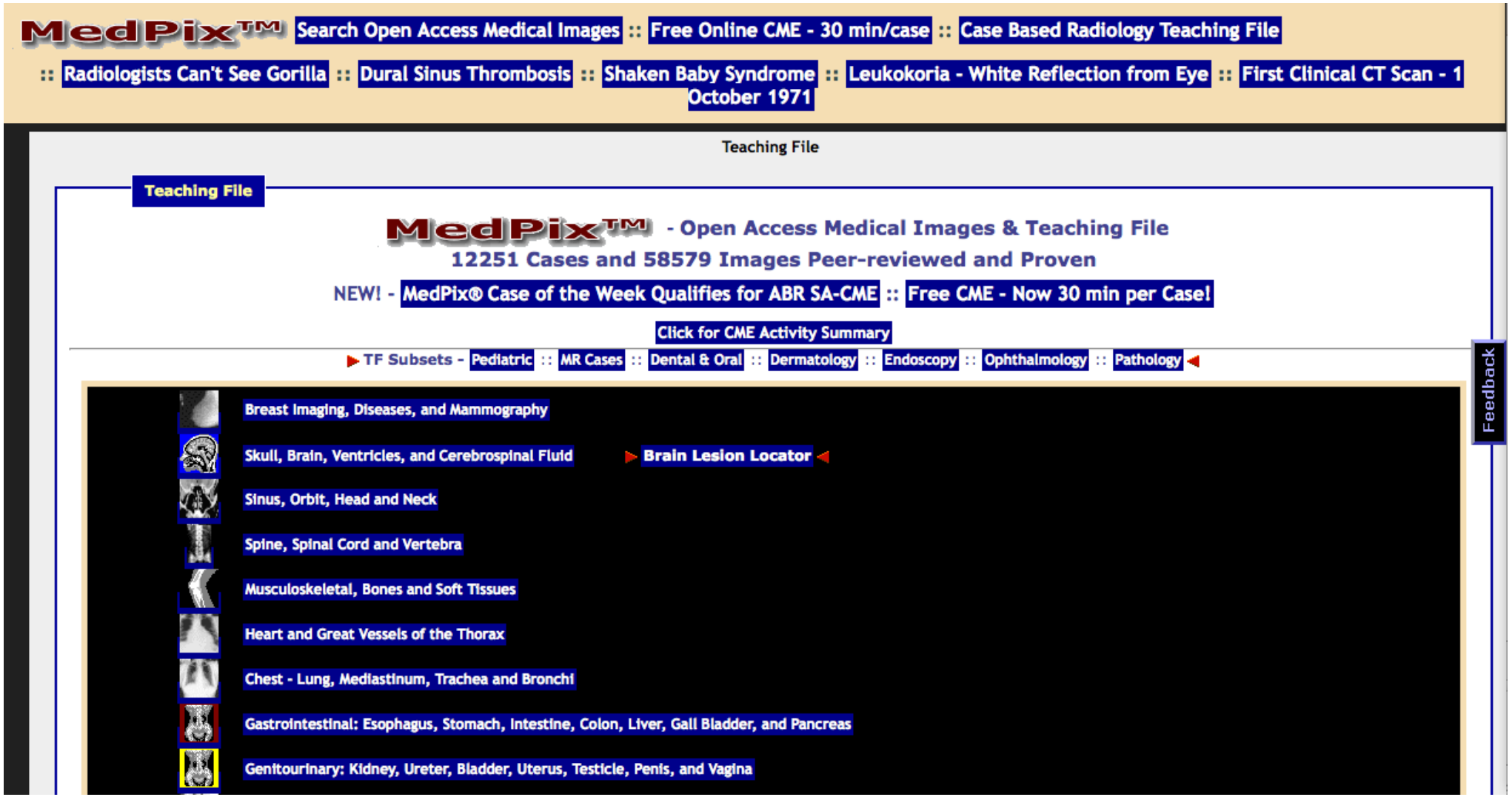
Digital anatomy: image database query (8/8)



DIGITALIZATION OF PAPER-BASED ATLASES

NOME ATLANTE	Autore/i	ULTIMA EDIZIONE CARTACEA	ULTIMA EDIZIONE ELETTRONICA	RIFERIMENTO	PREZZO INDICATIVO (US $)	SISTEMA OPERATIVO SUPPORTATO
De humani corporis fabrica	Andreas Vesalius	XVI sec	2 CD-ROM 13 CD-ROM (didattica) 2005	Octavo edition	75.00 850.00	Windows Macintosh UNIX
Atlas of Human Anatomy	Frank H. Netter	3rd	CD-ROM Versione 3.0 2003	Icon Learning Systems	50.00-70.00	Windows Macintosh
Gray's Anatomy	Henry Gray, Lawrence Hannister, Peter L Williams	38th	CD-ROM 1998	Churchill Livingstone	200.00-300.00	Windows
Grant's Anatomy	Anne M Agur, Arthur F. Dalley	11th	CD-ROM 2001	Grant	50.00-80.00	Windows
Sobotta anatomy	R. Putz, R. Pabst	21st	CD-ROM Versione 2.0 2003	Urban and Fischer	50.00-80.00	Windows
Imaging Atlas of Human Anatomy	Jamie Weir, Peter H. Abraham	2nd	CD-ROM 2001	Mosby	60.00-100.00	Windows Macintosh

The case of MedPix (1/3)



(http://rad.usuhs.edu/medpix/parent.php3?mode=simple)

The case of MedPix (2/3)

- MedPix – Medical Imaging Database – is a web-based multiplatform bioimage databank that integrates images and texts.
- Owned by the Uniformed Services University of Health Sciences (http://www.usuhs.mil/), Bethesda, MD
- Expected users:
  - Healthcare professionals (doctors, nurses, etc)
  - Healthcare workers
- Present statistics

The case of MedPix (3/3)

- The online material is organized by:
  - Pathologies
  - Localization
  - Captions
  - Patient's profile
- Started in 1999 (jan 2015 → 10 mln visualizations)
- High quality and high-yield material:
  - Most cases have a proven diagnosis (pathology, clinical followup);
  - teaching file cases are peer-reviewed by an Editorial Panel.