

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



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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 bioimage 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

- Ordinary/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)



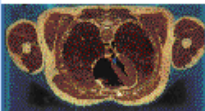
EXAMPLES

- **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



Home



Projects Based on the Visible Human Data Set

[Applications for viewing images](#)

[Sources of images and animations](#)

[Products](#)

[Mirror Sites](#)

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[Related Projects](#)

The Visible Human Project®

Overview

The Visible Human Project® is an outgrowth of the NLM's 1986 Long-Range Plan. It is the creation of complete, anatomically detailed, three-dimensional representations of the normal male and female human bodies. Acquisition of transverse CT, MR and cryosection images of representative male and female cadavers has been completed. The male was sectioned at one millimeter intervals, the female at one-third of a millimeter intervals.

The long-term goal of the Visible Human Project® is to produce a system of knowledge structures that will transparently link visual knowledge forms to symbolic knowledge formats such as the names of body parts.

The National Library of Medicine thanks the men and the women who will their body to science, thereby enabling medical research and development.

Further Information

• General Information

- A description of The Visible Human Project® [image data and how to obtain it](#) (includes license agreement documents).
- The Visible Human Project® [FactSheet](#).
- The Visible Human Project® [From Wikipedia, the free encyclopedia](#)
- [The Visible Human Project®: From Data to Knowledge: An update of ongoing National Library of Medicine VHP initiatives](#).
- [Digitally encoded videos](#) - requires RealPlayer.
- A sampler of [images and animations](#) from the Project.
- Belarusian translation of The Visible Human Project® [Overview](#)
- Russian translation of The Visible Human Project® [Overview](#)

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 alignment 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 [pixel ²]	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



Aims

- Digital healthy human (male and female) anatomy library

Medical specialty

- Anatomy, healthy subjects (educational aim)

Number of cases

- 2 cases

Selection criteria

- Protocol established 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



Fotografie	Radiografie	TAC	MR	PET	SPECT	ECO
<p><i>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</i></p>	<p><i>15 radiografie di prova (solo per il dataset maschile)</i></p>	<p><i>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)</i></p>	<p><i>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)</i></p>			
<p><i>Su pellicola da 70 mm colore RGB. Dimensione del pixel 0.144mm per 0.144mm, intervallo di separazione:1mm</i></p>						

ATTRIBUTES OF THE VHD: METHODOLOGY



Bioimage organization

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



The screenshot shows the NIH U.S. National Library of Medicine website. The top navigation bar includes a search box and links for 'Databases', 'Find, Read, Learn', 'Explore NLM', 'Research at NLM', and 'NLM for You'. A 'Contact NLM' link and social media icons are also present. The main content area is titled 'The Visible Human Project' and 'Projects Based on the Visible Human Data Set'. A sidebar on the left lists various resources like 'Applications for viewing images', 'Sources of images and animations', 'Products', 'Mirror Sites', 'Tools', 'Media Productions', and 'Related Projects'. The main text lists several projects, including 'The University of Michigan's Visible Human Project', 'Med Image', 'BCS Grid Data Blade', 'WISE-MD', 'iVoxel Browser', 'VHPPProject', 'Net Anatomy', 'virtusMed', 'Cross Sectional Anatomy', 'Real-time Slice Navigator', 'Radiologic Anatomy Atlas Viewer', and 'Visible Human Female Head and Pelvis Browsers'.

NIH U.S. National Library of Medicine

Search

Databases Find, Read, Learn Explore NLM Research at NLM NLM for You Contact NLM

Home



The Visible Human Project
Projects Based on the Visible Human Data Set
Applications for viewing images

- [The University of Michigan's Visible Human Project](#) provides 2D and 3D navigational browsers to Visible Human content for educational purposes.
- [Med Image](#): Macintosh application showing transverse, sagittal, and coronal views of the male pelvis, female head to pelvis, and female legs.
- [BCS Grid Data Blade](#), Java applet that provides 2D views of the Visible Human Male at arbitrary inclinations- from Barrodale Computing Services, Ltd.
- [WISE-MD](#), Web Initiative for Surgical Education Modules for undergraduate or graduate medical education, from NYU School of Medicine.
- [iVoxel Browser](#) Java- based web browser showing voxel data, surface models, annotations, body system relationships, volume rendering, and stereo 3D viewing. Software under development at the University of Michigan.
- [VHPPProject](#) (VHP Projection) from Australia's Griffith University is a web portal interface allowing exploration of volumetric data via a simple web browser.
- [Net Anatomy](#) Multi-modal anatomy teaching tool from Scholar Educational Systems, Inc.
- [virtusMed](#) an interactive computer system designed for teaching anatomy and medical imaging procedures such as ultrasound.
- [Cross Sectional Anatomy](#) viewer from Loyola University (Chicago) Stritch School of Medicine.
- [Real-time Slice Navigator](#) - from the Computer Science Department Peripheral Systems Lab, Ecole Polytechnique, Lausanne, Switzerland.
- [Radiologic Anatomy Atlas Viewer](#), developed by Robert Livingston, Clinical Assistant Professor, University of Washington.
- [Visible Human Female Head and Pelvis Browsers](#) from the University of Michigan's Digital Microscopy and Scientific Visualization Laboratory (requires a Java enabled Web client).

Projects Based on the Visible Human Data Set

[Applications for viewing images](#)

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<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, texture, shapes)
- Example: colour histogram

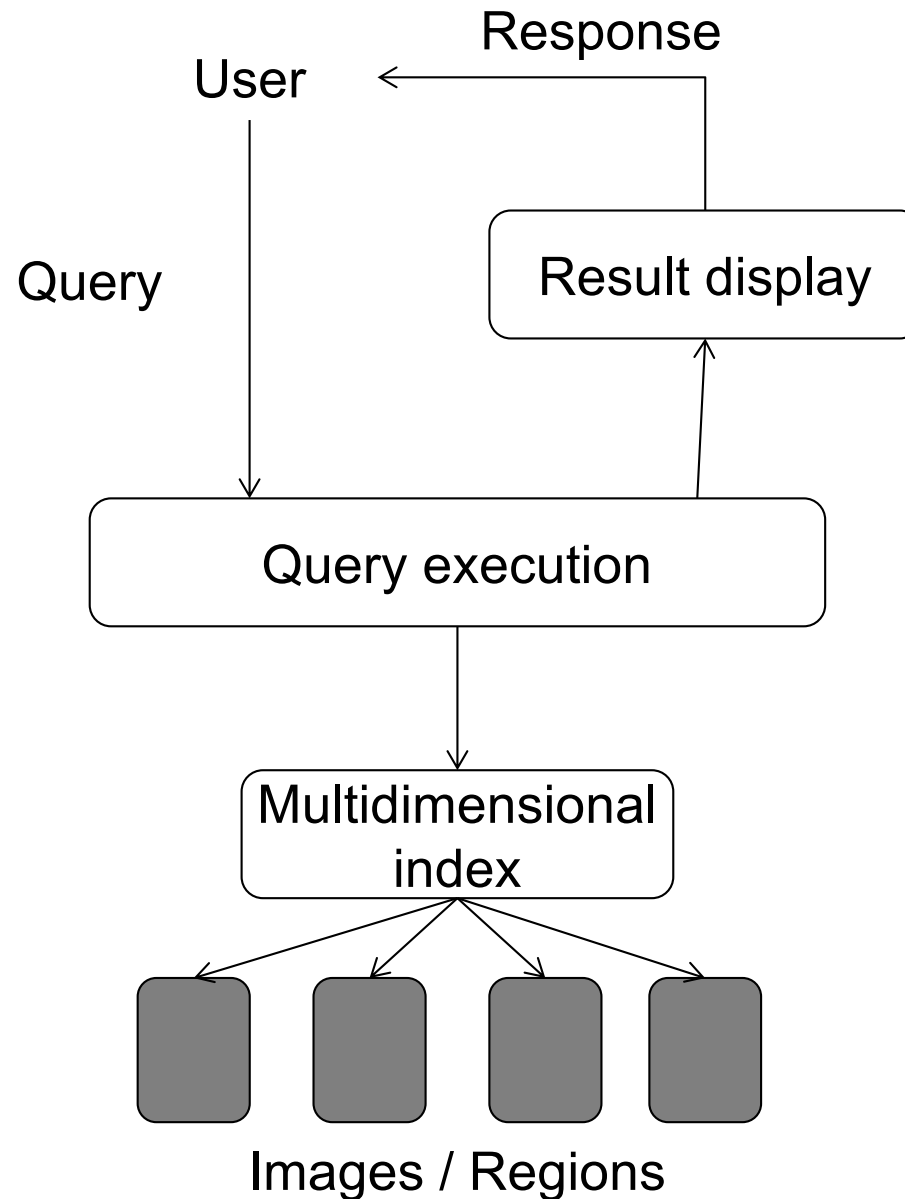
•Region extraction methods:

- Group the pixels belonging to a region

Digital anatomy: image database query (3/8)



Query workflow



Digital anatomy: image database query

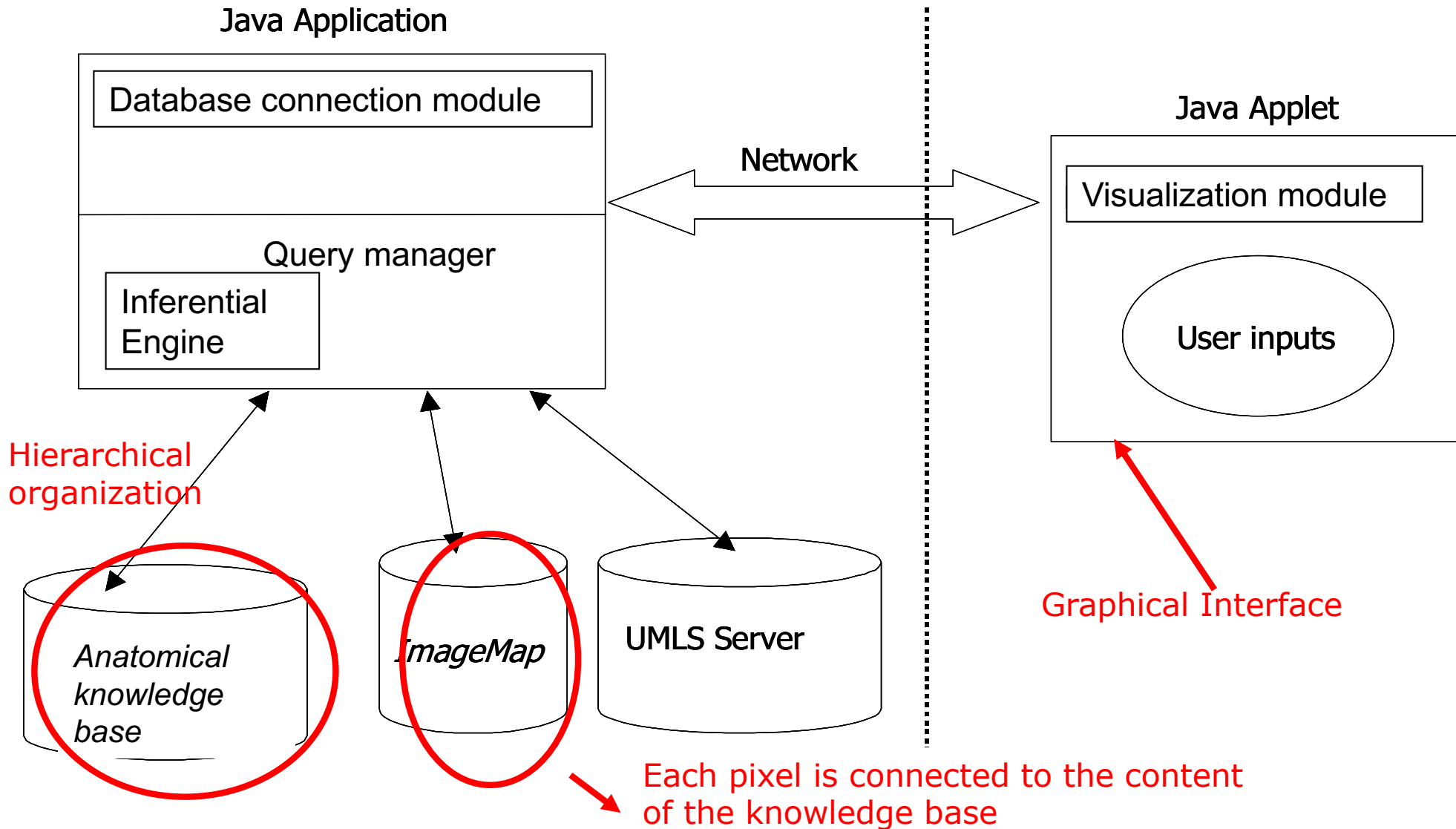
(4/8)



Server side

Structure

Client side



Digital anatomy: image database query

(5/8)



Connection | **Term search** | Semantic search | Visual browsing | Constrained query

Retrieved concepts: 53

English_Term	Body_System	Body_Region
c1 atlas vertebra	skeletal system	neck
c2 axis vertebra	skeletal system	neck
c3 vertebra	skeletal system	neck
c4 vertebra	skeletal system	neck
c5 vertebra	skeletal system	neck
c6 vertebra	skeletal system	neck
c7 vertebra	skeletal system	neck
first coccygeal vertebra	skeletal system	pelvis
fourth coccygeal vertebra	skeletal system	pelvis
intervertebral disk, axis-c3	articul...	neck
intervertebral disk, c3-4	articul...	neck
intervertebral disk, c4-5	articul...	neck
intervertebral disk, c5-6	articul...	neck
intervertebral disk, c6-7	articul...	neck
intervertebral disk, c7-11	articul...	neck
intervertebral disk, 11-2	articul...	neck
intervertebral disk, 12-3	articul...	neck
intervertebral disk, 13-4	articul...	neck

Is-a hierarchy for c7 vertebra

- anatomical entity
 - physical structure
 - organ
 - full organ
 - bone
 - irregular bone
 - vertebra
 - cervical vertebra
 - c7 vertebra**

Term Name: C7 vertebra
 Term UI: L0768892
 RCD99/PT17N939
 UWDA99/SY1 2525

Signed by:

Concept Name: Seventh cervical vertebra
 Definition: no definition found.

Body Region: *
 Body System: *

NOT AND OR NOT

Find All

Search by term: exact Match
 vertebra **Search**

c7 vertebra

Short definition

It represents the seventh cervical vertebra. It is an unpaired bone of the vertebral column. It is constituted by a bifurcated spinous process, a main body named centrum and two neural arches that forms the vertebral foramen containing the spinal cord.

Taxonomy **Synonyms**

UMLS Metathesaurus

Concept Code UI: **C0223176**
 Term Code UI: **L0768892**

Store **Stop**

Digital anatomy: image database query (6/8)



Connection Term search **Semantic search** Visual browsing Constrained query

Retrieved concepts: 16

- ethmoid bone
 - cribriform plate, left
 - olfactory foramina
 - cribriform plate, right
 - olfactory foramina
 - lateral mass, left
 - inferior nasal concha
 - lamina orbitalis
 - middle concha
 - superior concha
 - lateral mass, right
 - inferior nasal concha
 - lamina orbitalis
 - middle concha
 - superior concha
 - perpendicular plate
 - crista galli

Hierarchical level 8 Search by meaning

Set relation constraint

Definition

It is a part of ethmoid bone. It joins with the frontal bone to form the floor of the anterior cranial fossa. It is perforated by many tiny olfactory foramina.

Digital anatomy: image database query

(7/8)



Location: <http://corbamed.bioing.polimi.it/anat/>

Connection Term search Semantic search **Visual browsing** Constrained query

organ
bone
brain
eye
genital organ
gland
kidney, left
kidney, right
pancreas
parotid gland, left
parotid gland, right
prostate
suprarenal gland, left
suprarenal gland, right
thyroid, left

Image list 10
Slice #579
Slice #580
Slice #581
Slice #582
Slice #583
Slice #584
Slice #585
Slice #586
Slice #587
Slice #588

100 kidney, left

kidney, left
is-a-kind-of gland
is-part-of urinary system
is-located-in abdomed

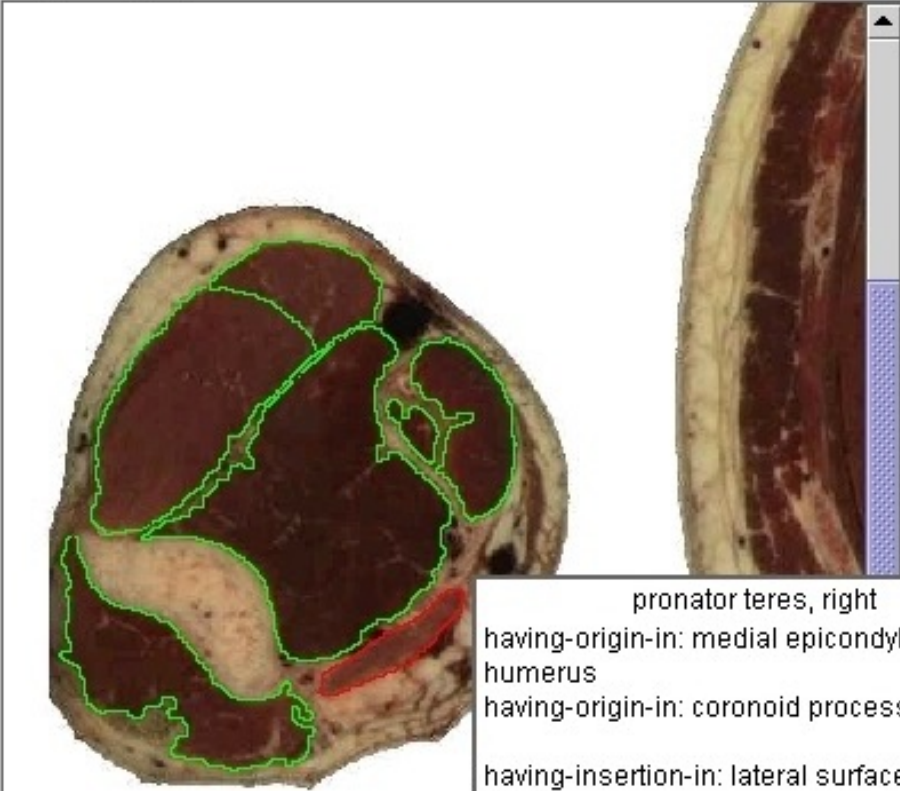
584

Digital anatomy: image database query (8/8)



Connection Term search Semantic search Visual browsing **Constrained query**

slice # 1584 Result list pronator teres, right



category muscle

body part arm

body system

consisting of

being innervated by

having origin in

having insertion in

relation of

ed by

from

f

Update

Query

pronator teres, right
having-origin-in: medial epicondyle of humerus
having-origin-in: coronoid process of ulna
having-insertion-in: lateral surface of shaft of radius
acting-as-pronator-of: forearm
acting-as-flexor-of: forearm
being-innervated-by: median nerve

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	3 rd	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	38 th	CD-ROM 1998	Churchill Livingstone	200.00-300.00	Windows
Grant's Anatomy	Anne M Agur, Arthur F. Dalley	11 th	CD-ROM 2001	Grant	50.00-80.00	Windows
Sobotta anatomy	R. Putz, R. Pabst	21 st	CD-ROM Versione 2.0 2003	Urban and Fischer	50.00-80.00	Windows
Imaging Atlas of Human Anatomy	Jamie Weir, Peter H. Abraham	2 nd	CD-ROM 2001	Mosby	60.00-100.00	Windows Macintosh



The case of MedPix (1/3)

MedPix™ Search Open Access Medical Images :: Free Online CME - 30 min/case :: Case Based Radiology Teaching File

:: Radiologists Can't See Gorilla :: Dural Sinus Thrombosis :: Shaken Baby Syndrome :: Leukokoria - White Reflection from Eye :: First Clinical CT Scan - 1 October 1971

Teaching File

Teaching File

MedPix™ - Open Access Medical Images & Teaching File

12251 Cases and 58579 Images Peer-reviewed and Proven

NEW! - MedPix® Case of the Week Qualifies for ABR SA-CME :: Free CME - Now 30 min per Case!

[Click for CME Activity Summary](#)

▶ TF Subsets - [Pediatric](#) :: [MR Cases](#) :: [Dental & Oral](#) :: [Dermatology](#) :: [Endoscopy](#) :: [Ophthalmology](#) :: [Pathology](#) ◀

[Breast Imaging, Diseases, and Mammography](#)

[Skull, Brain, Ventricles, and Cerebrospinal Fluid](#)

▶ [Brain Lesion Locator](#) ◀

[Sinus, Orbit, Head and Neck](#)

[Spine, Spinal Cord and Vertebra](#)

[Musculoskeletal, Bones and Soft Tissues](#)

[Heart and Great Vessels of the Thorax](#)

[Chest - Lung, Mediastinum, Trachea and Bronchi](#)

[Gastrointestinal: Esophagus, Stomach, Intestine, Colon, Liver, Gall Bladder, and Pancreas](#)

[Genitourinary: Kidney, Ureter, Bladder, Uterus, Testicle, Penis, and Vagina](#)

Feedback

(<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

Current MedPix® Inventory:

- **43470 Registered Users**
- **58579 Captioned Images - [Search Images](#)**
- **12251 Peer Reviewed and Approved Cases - [List TF Diagnoses](#)**
- **7373 Approved Disease Topic Factoids - [List All Topics](#)**
- **9617 Topics Submitted**



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.