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▶ **To cite this version:**

Katerin Romeo-Pakker, B Wathek, Jm Rocchisani. TYPOLOGY IN WEB-BASED MEDICAL IMAGE DATABASES. 2nd International Conference on E-Health & Telemedicine, ICEHTM 2014 , Assist. Prof. Dr. Tayseer Al-Shanableh, Dr. Fahme Dabaj, May 2014, Istanbul, Turkey. hal-01664265

HAL Id: hal-01664265

https://normandie-univ.hal.science/hal-01664265

Submitted on 14 Dec 2017

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TYPOLOGY IN WEB-BASED MEDICAL IMAGE DATABASES

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Abstract

Sharing records and images between physicians and researchers becomes nowadays very common. Many areas of medical research are concerned. Starting from physicians searching for similarities for the diseases observed, and the researchers applying new algorithms, many persons need easily accessible medical image databases in their specialization area. In this paper, we describe different web-based collections of medical images and we analyse the functionalities and goals of these databases.

For the functional point of view, we can find two types of Medical Image Databases:

Firstly, Databases for Research are composed of two groups according to their main goals.

Databases for Clinical Research aim at providing the practitioner with convenient tools for storing and retrieving large collection of images, and performing clinical studies with them.

Databases for Image Processing Research and Challenges collect a small amount of images related to a particular topic, in order to provide the researcher data to test their algorithms.

Secondly, Databases for Educational use aim at offering to the students images and learning resources such as image description and classification.

Keywords

Web-based, medical images, database, functionality.

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Abstract
Sharing records and images between physicians and researchers becomes nowadays very common. Many areas of medical research are concerned. Starting from physicians searching for similarities for the diseases observed, and the researchers applying new algorithms, many persons need easily accessible medical image databases in their specialization area. In this paper, we describe different web-based collections of medical images and we analyse the functionalities and goals of these databases.

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1. INTRODUCTION

Medical imaging has become a major tool to examine various diseases, to study patient health, to document the presentation of clinical findings and to do the medical follow-up of the patients. Medical image data provides visual evidence of many diseases thus generating a large number of digital images to support clinical decisions. The problem of archiving those medical image collections has been addressed with different solutions in order to create image databases. Reference images are also needed for various combinations of modalities: CT (computed tomography), PET (Positron emission tomography), MRI (Magnetic resonance imaging), US (ultra sound), for various locations (heart, brain, lung…) and diseases. [1]

Sharing records and images within a health system started on the internal sharing basis. As the use of internet became more usual for medical studies, physicians and researchers in the medical area started to share their medical image collections through web-based image databases. The need comes from the physicians searching similarities for the diseases they observed on their patients [2][3]. Researchers in the medical field apply their work on the images in a database in order to compare and evaluate the algorithms they develop. They need easily accessible image databases. Many areas of medical research are concerned. Some examples would be the biomedical database of digitized spine X-ray images [4], presentation of dermatological images [5], brain CT Image database [6]. Another field of research concerns the difficulty of the image retrieval through distance measures [7], and according to the content of the images [8][22].

In this paper we will compare several web-based medical image databases in order to analyse their objectives, functionalities and their typology. Many databases are free for researchers and physicians, somehow the access to these databases are secured with an identifier and a password given by an administrator of the database.

2. OVERVIEW OF MEDICAL IMAGE DATABASE TYPES

Medical image database systems store images with complementary data of textual information, presenting the information on images for transfer and visualisation. Most often, these systems are restricted to query a database through keywords. A medical image database system must have a flexible architecture along with a wide variety of functionalities supporting clinical, academic and research tasks.

For the functional point of view, we can find two types of Medical Image Databases:
Firstly, Databases for Research are composed of two groups according to their main goals.

- Databases for Clinical Research (section 3) aim at providing the practitioner with convenient tools for storing and retrieving large collection of images, and performing clinical studies with them.
- Databases for Image Processing Research and Challenges (section 4) collect a small amount of images related to a particular topic, for providing the researcher data to test their algorithms.

Secondly, Databases for Educational use (section 5) aim at offering to the students images and learning resources such as image description and classification.

3. DATABASES FOR CLINICAL RESEARCH

3.1. Lung Image Database Consortium

This Consortium is created by a group of physicians from Cornell University. In 1992, ELCAP decided to start the Early Lung Cancer Action Program and to achieve early diagnosis, treatment, and ultime cure of lung cancer through the advances of research in a collaborative network. Today research is ongoing, incorporating larger pools of patient data to reaffirm the findings and start new directions. Public Lung Image Database [9] provides a set of CT images to compare the results from computer-aided diagnosis systems and to assess stability or change in lesion sizes in CT studies. This database serves as an important resource for researchers who develop new methods for early detection and screening for lung cancer.

As seen in Fig.1 some of the images are marked by radiologists and 3D images of the tumors are calculated from these data.

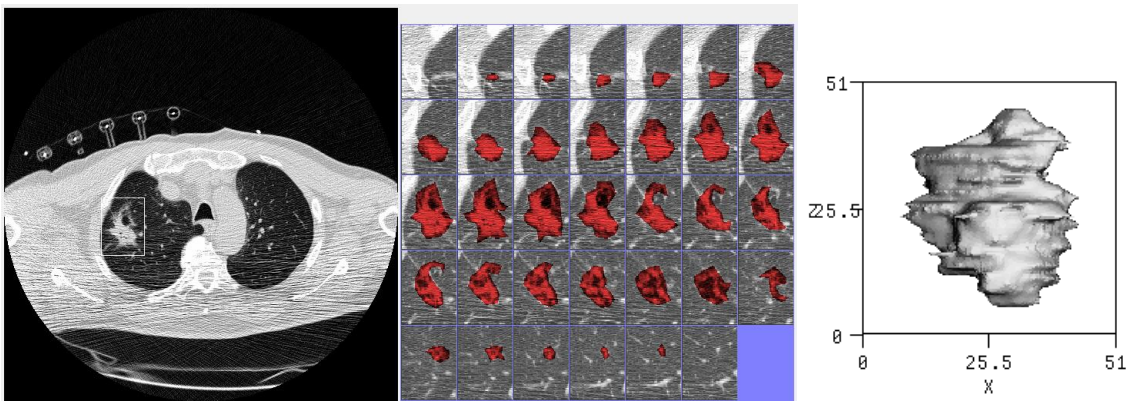


Fig. 1 An example of Public Lung image database (Lung image database Consortium, I-ELCAP), Single large nodules case with radiologist markings and the 3D image associated to this tumor.

3.2. Open Access Medical Image Repository

Open Access Medical Image Repository [10] is a portal for medical image databases and hosts multiple collections of data. For example National Biomedical Archive (NBIA) includes Lung Image Database Consortium (LIDC), Reference Image Database to Evaluate Response (RIDER), Breast MRI, Lung PET/CT, Neuro MRI, CT Colongraphy, Virtual Colonoscopy, Osteoarthritis Initiative, PET/CT phantom scan collection.

Image Repository gathers some other medical image databases like: BIRN/XNat, MIDAS, Cornell Visualization and Image Analysis (VIA) Group, UT Health Science Center Image Collections, OmniMedicalSearch.com: Medical Image Databases. and some other sites dedicated to specific data collections like Mammographies, Retinal images, chest radiographs (See Fig.2).

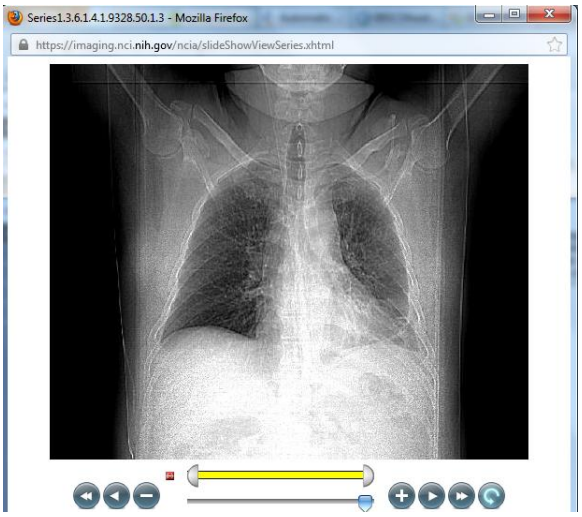
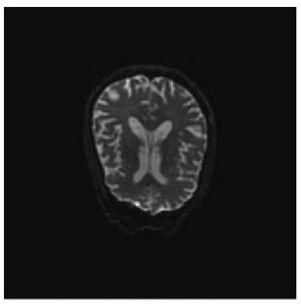


Fig. 2 Open Access Medical Image Repository, the selected DICOM images can be seen in Cine mode also.

3.3. Alzheimer's Disease Neuro Imaging (ADNI)

Alzheimer's Disease Neuro imaging Initiative [11], unites researchers who collect, validate and utilize data such as MRI and PET images, genetics, cognitive tests, CSF and blood biomarkers as predictors for the disease. The goal of the project is to determine the relationships among the clinical, cognitive, imaging, genetic and biochemical biomarker characteristics of the spectrum of Alzheimer's disease. An example of MRI Image data can be seen in Fig.3 below.



Raw MRI using MP-RAGE

Raw ImageType	Image Description	Image Contributor	Preprocessed	Postprocessed
MP-RAGE	MPR; GradWarp; B1 Correction; N3; Scaled ADNI 1/GO)	MR Core (Mayo Clinic)	x	
	MT1; GradWarp; N3m (ADNI 2)	MR Core (Mayo Clinic)	x	
	image	Thompson Group (UCLA-LONI)	x	
	BEaST normalized MPRAGE	Eskildsen (MNI)	x	
	BEaST manual brain mask	Eskildsen (MNI)	x	
	FreeSurfer Cross-Sectional Processing	Schuff Group (UCSF)		x
	FreeSurfer Longitudinal Processing	Schuff Group (UCSF)		x
	Hippocampal Mask	Schuff Group (UCSF)		x
	Jacobian	Thompson Group (UCLA-LONI)		x
	MAPER segmentation	Heckemann (Imperial College)		x
	MIDAS Whole Brain Mask	Fox Group (University College)		x
T2-weighted	Total Intracranial Volume Brain Mask	Carmichael, O and DeCarli, C		x
Diffusion-weighted	Eddy current corrected image	Thompson Group (UCLA-LONI)	x	
	EPI current corrected image	Thompson Group (UCLA-LONI)	x	
	corrected FA image	Thompson Group (UCLA-LONI)	x	
	corrected MD image	Thompson Group (UCLA-LONI)	x	

Fig.3 MRI Image data available in the ADNI Database.

The collection of these images aims to develop biomarkers to track the progression of Alzheimer's disease and changes in the underlying pathology. After a first screening and the baseline, data is collected every 3 months until 48 months.

3.4. Laboratory of Neuro Imaging (LONI)

Laboratory of Neuro Imaging [12] (UCLA) has created a user-friendly environment for archiving, searching, sharing, tracking and disseminating neuro imaging and related clinical data. Image Data Archive (IDA) is very much utilized in research projects worldwide and uses the modalities MRI, PET, MRA, SPECT, DTI and other ones. A flexible data de-identification engine and encrypted file transmission ensure compliance with patient-privacy regulations.

Brain atlases are built from one or multiple representations of the brain. They show the brain structure and function with the application of appropriate registration and warping, indexing schemes and nomenclature systems. Fig. 4 shows an example of a human brain atlas.

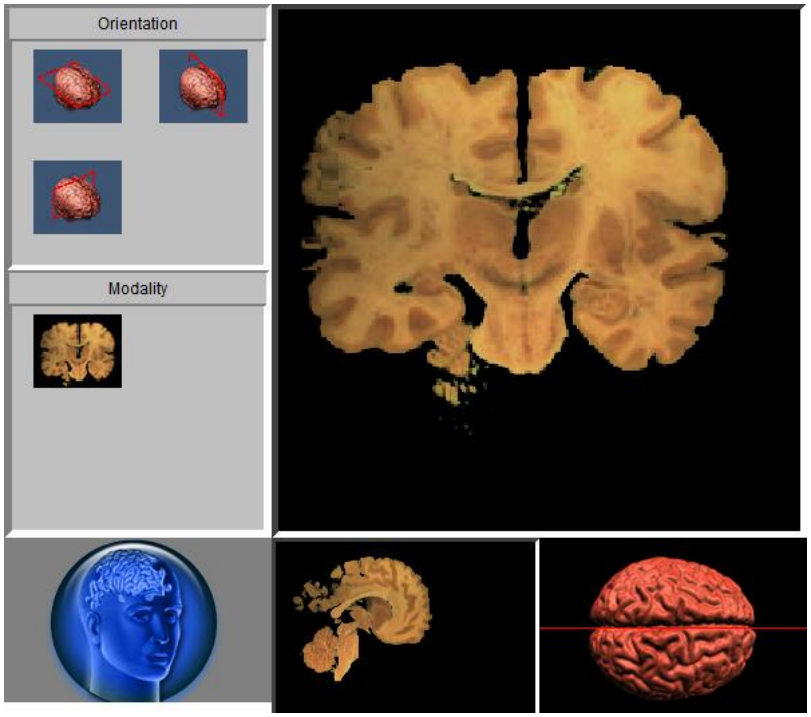


Fig. 4 An example of Human brain atlas in the LONI image database.

4. IMAGE PROCESSING RESEARCH DATABASE

Image processing papers are full of descriptions of new algorithms to be applied to medical images. To compare the newly proposed algorithm with the state of the art and to improve the performance of medical image analysis algorithms, Grand Challenges in Medical Image Analysis [19] are organized. These challenges gather databases of test to be used during the workshops. A platform for sharing and visualizing data, algorithms and evaluation is developed.

4.1. Challenges

In conjunction to the major medical image processing conferences, challenges are organized each year for selecting the best algorithms that provide a solution to a specific problem such as the segmentation of Lung nodules. Competitors have to apply their algorithms on the images. A portal is created to allow access to the image database of those challenges. (Fig. 5)

4.1.1. ISBI Grand Challenges

Grand Challenges in Medical Image Analysis [23] aim to focus the attention of researchers on a problem in the medical image analysis field. The comparison of the different methods used to solve the given challenge may contribute to accelerate the resolution of the driving problem. The organizers consider that the key component to a successful Grand Challenge is the quality of data that should represent the characteristic conditions of the challenged problem. This data is ideally accompanied by the representative ground truth and metrics that characterize the method's performance.

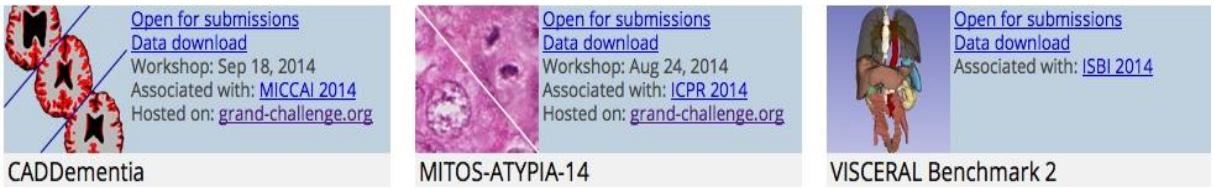


Fig. 5 Example of some challenges open for competitors in 2014

4.1.2. MICCAI

The Medical Image Computing and Computer Assisted Intervention Society (The MICCAI Society) [23] encourages the promotion and the facilitation of research in the field of medical image computing, computer assisted intervention and medical robotics. They organize Workshops and challenges on different topics covered by the conferences. Datasets are gathered for testing the algorithms of several research groups and the results are evaluated and compared. Figure 6 shows an image explaining the detection of coronary artery stenoses in cardiac CTA (computed tomography angiography) images from the challenge dataset [24].

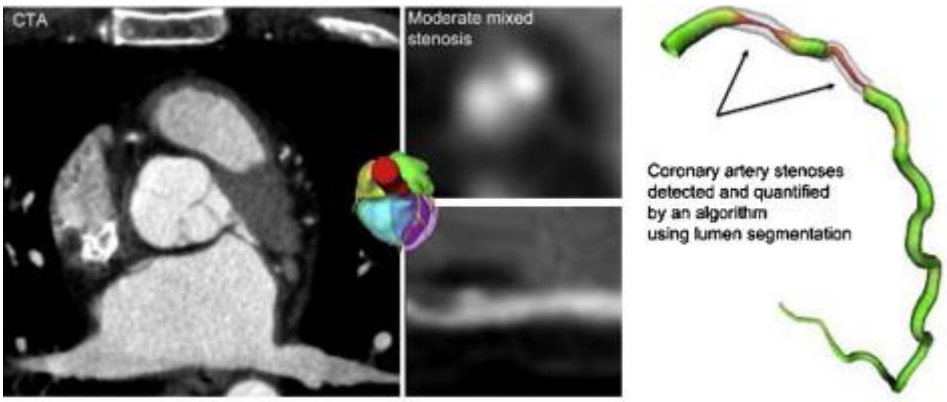


Fig. 6 MICCAI Challenge on Coronary artery stenoses detection and quantification and lumen segmentation in CTA images.

4.2. Simulations and Phantoms

4.2.1. OncoPET_DB

OncoPET_DB is a freely distributed database of realistic simulated whole body 18G-FDG PET images for oncology [13]. Its goal is to provide the scientific community with a database containing realistic small lesions of calibrated uptakes. A complex model of 18F-FDG patient is built based on the Zubal phantom with activity distributions in the main organs of interest. The data is derived from a series of 70 clinical cases (Fig.7). A model of lesions is proposed corresponding to real lymphoma patients. A human observer detection study determines the lesion contrast levels in order to cover the entire range of detectability. The simulated database is generated with PET-SORTEO Monte Carlo simulation tool [20] which is validated against the geometry of the ECAT EXACT HR+. This database is useful to evaluate algorithms that may influence contrast recovery, to carry out observer studies or test computer-aided diagnosis methods.

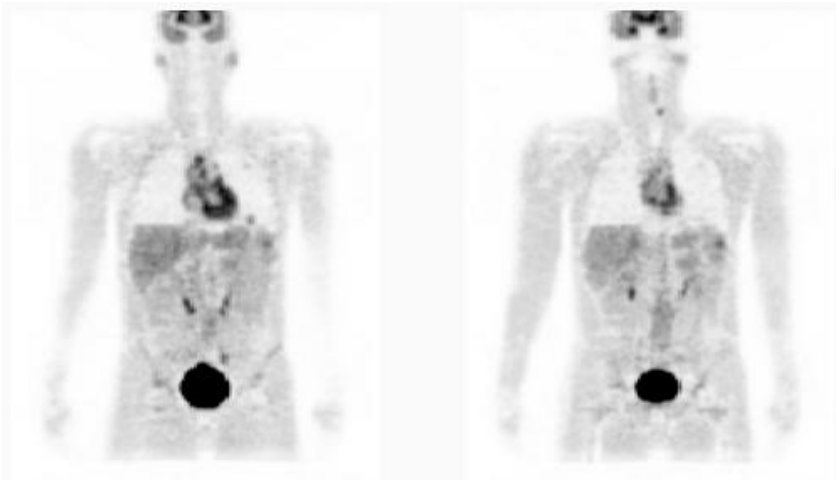


Fig. 7 OncoPET_DB simulated whole body 18G-FDG PET images for oncology.

4.3. Tools for building Databases

4.3.1. SHANOIR

It means Sharing NeurO Imaging Ressources, it is an open source neuro informatics platform designed to share, archive, search and visualize neuro imaging data. Shanoir [14] is organized as a repository of neuro imaging files coupled with a relational database where additional metadata is stored. It has a web interface or web services that can be used by heterogeneous applications. This database allows researchers, physicians, students to undertake research projects with remote collaboration. It is a secure J2EE application carried out by the VisAGeS Team, based at IRISA (INRIA Rennes – Atlantic Brittany Research Center, France).

4.3.2. MIDAS

MIDAS [25] is an acronym for The Multimedia Digital Archiving System. It is an open-source toolkit for a flexible and easy management, indexing, visualization, and processing of large data including medical images. Multimedia technologies and customization tools are implemented for an easy use of resources. It is used by well known institutions such as the National Library of Medicine (NLM), the National Institutes of Health (NIH), the National Cancer Institute (NCI), the Optical Society and the Insight Journal publishing system.

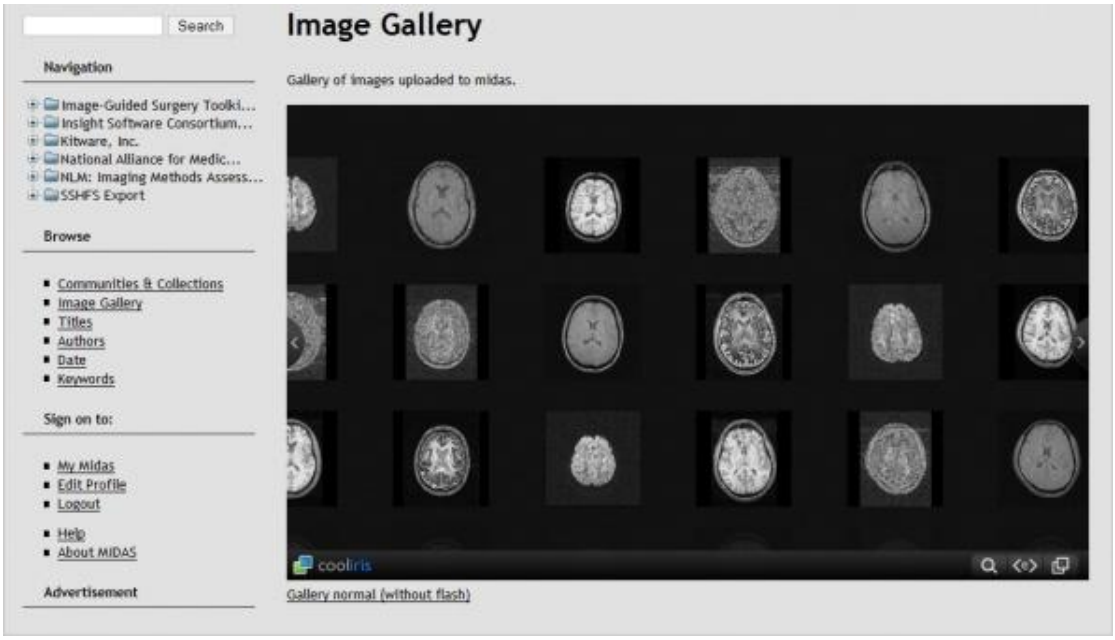


Fig. 8 MIDAS generated image gallery of the data stored in the system.

4.3.3. XNAT

XNAT [26] is an open source imaging informatics extensible platform, developed by the Neuroinformatics Research Group at Washington University that provides storage, management, processing, access, and quality assurance tasks for medical images and associated data (Fig. 9). It is used as Institutional Repository by many institutions such as Iowa University, and Emory University.



Fig. 9 Services provided by XNAT.

5. MEDICAL IMAGE DATABASES FOR ACADEMICAL PURPOSES

Medical Image Databases are widely used in education. Images are visual confirmation of the lectures, case studies, medical research. We give some examples of image databases where physicians, researchers, students, hospital staff can find examples of interesting cases.

5.1 Atlas

Anatomical atlases are very useful for educational purposes. A portal assembling Databases on medicine and molecular Biology, Med-DB [21], gives a certain number of image databases.

One of them, Harvard Medical School, proposes a brain image database named The Whole Brain Atlas [15]. Brain images are shown with the following characteristics: Normal brain, Cerebrovascular Disease (stroke or "brain attack"), Neoplastic Disease (brain tumor), Degenerative Disease, and Inflammatory or Infectious Disease. In Figure 10, Normal Brain Anatomy in 3-D with MRI/PET is shown. The technology used for these images are now in javascript, old Atlas Navigator was in java which takes longer to download the images.

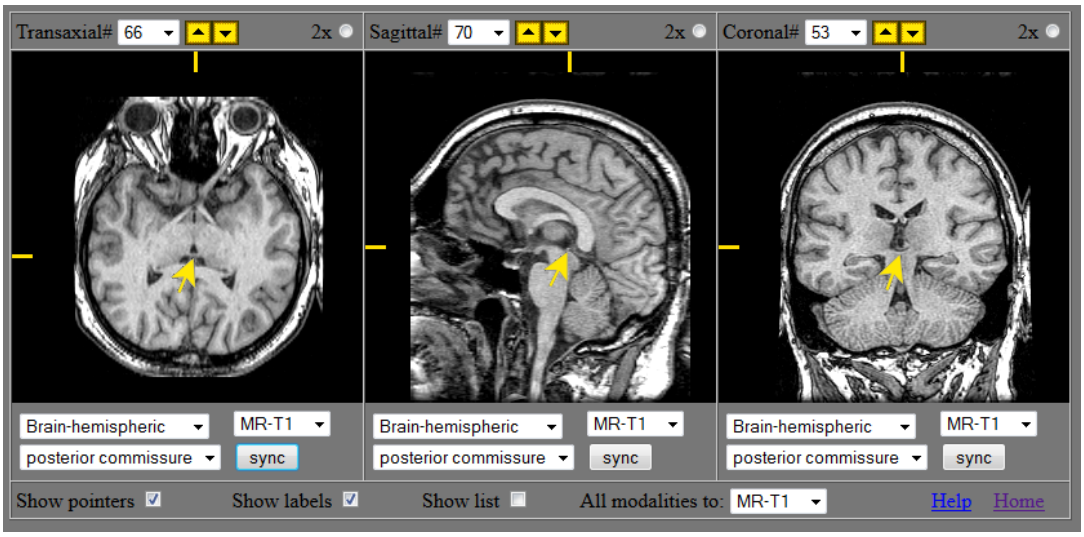


Fig. 10 The whole brain atlas from Harvard Medical School, Normal Anatomy in 3-D with MRI/PET

5.2 IMAIOS

This is a database where one can find anatomical atlases, articles state of the art, e-cases [16]. The website is dedicated to online medical training for healthcare professionals. It is a repository of medical cases shared by the Healthcare community. The images are shown in a viewer with functionalities like zoom, measure, adjust brightness. An example of an e-case of a peritonis on salpingitis is shown in Figure 11.

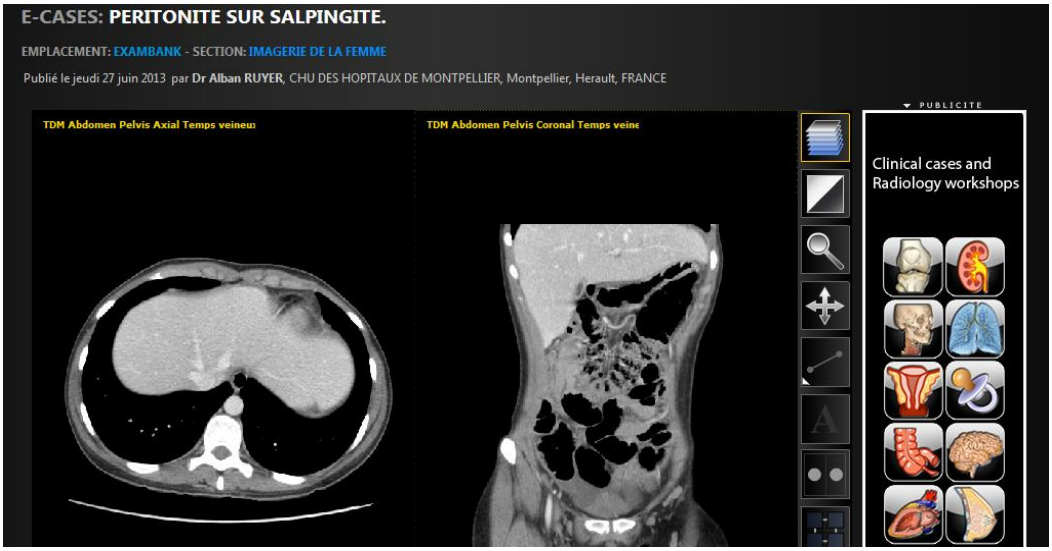


Fig. 11 Imaios database, e-case of peritonitis on salpingitis.

5.3 Aunt Minnie

This website shows case archives with images since 1999 till now. This database is specially oriented for continuing education for physicians and other healthcare professionals. Various patient cases are proposed with quizzes. [17] The system gives to members the tools to author and share a clinical case containing a patient history, photos, x-rays and other diagnostic information. (Fig. 12)

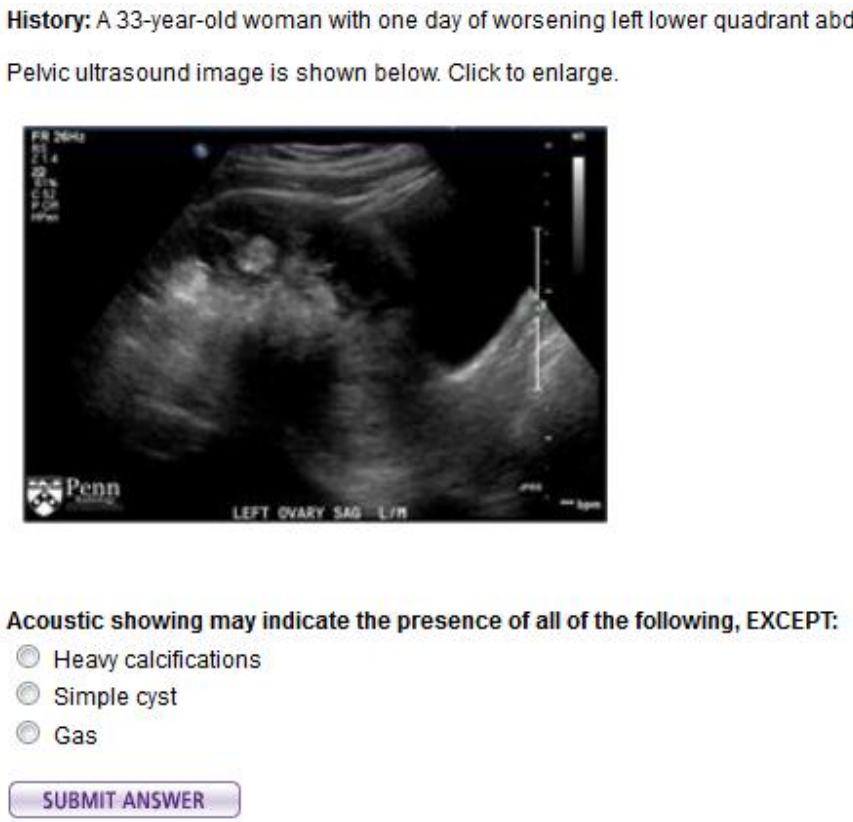


Fig. 12 Education database on Aunt Minnie website showing the case of the day with a quizz.

5.4 MedPix

MedPix is a free online Medical Image Database and Radiology Portal, provided by the Department of Radiology and Biomedical Informatics, Uniformed Services University, Bethesda, MD. [18] It is a web-enabled cross-platform database, integrating images and textual information. Teaching files are intended for physicians and nurses, allied health professionals, medical students, graduate nursing students and other post-graduate trainees. The database is organized by disease organ system, pathology category, patient profiles and by image classification and caption. Search engines work through images and text search. Users may register and use additional features like credits, quizzes, uploading and editing. An example image with thumbnail pictures is shown in Fig. 13.

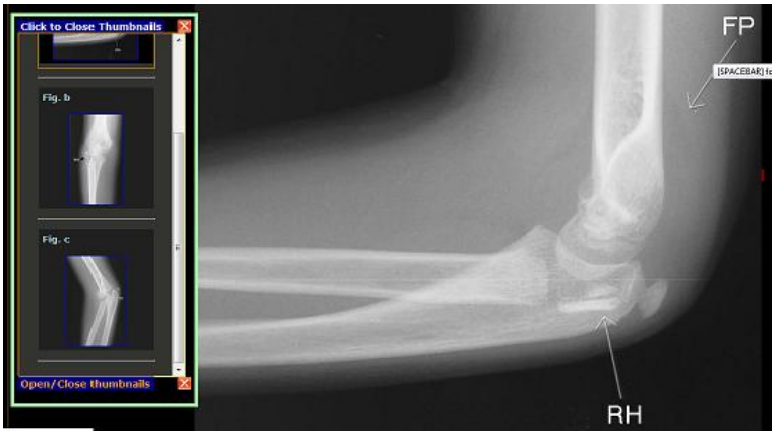


Fig. 13 MedPix presents a patient case with an elbow problem.

5.5. Microscopy

Microscopic images are not exclusive of medical image database. Numerous sites offer access to learning resources and images of microscopic slices of organs in the fields of Histology and Pathology.

5.5.1 Histology

The Histology learning system [27] is a website, where the user can select by various ways images and view them in a virtual slidebox.

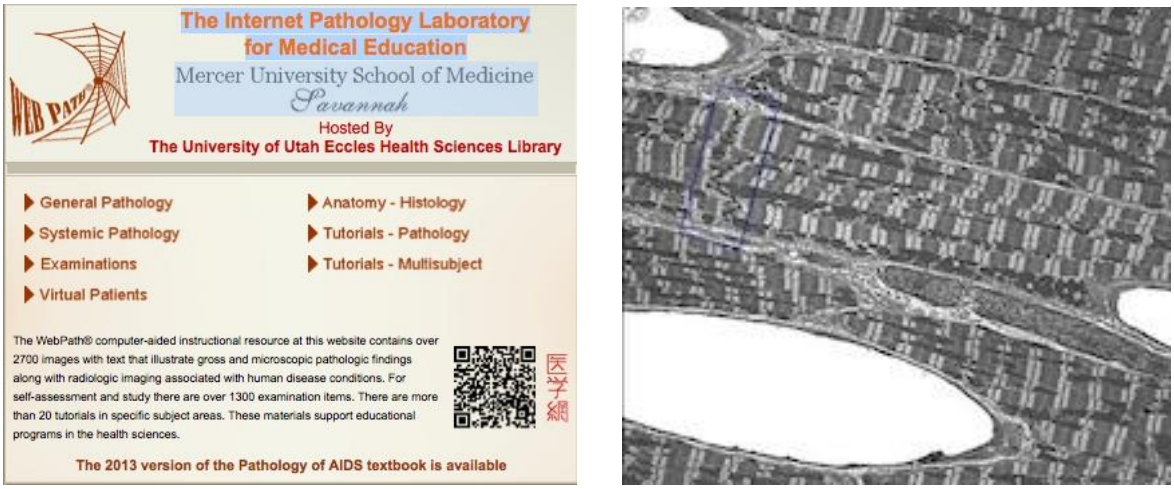


Fig. 14 The Histology learning system, main page (left) and cardiac muscle image (right).

5.5.2 Pathology

WebPath, The Internet Pathology Laboratory for Medical Education [28], is an example of website presenting a database of learning resources and photomicrographs of pathological cases. Navigation to learning materials and images is performed thanks to hierarchical menus, and images are displayed statically (Fig. 15).



Fig. 15 WebPath, main page (left) and myocardial infarction image (right).

6. CONCLUSION

The most popular medical image databases have been analysed and compared in this article. Many other databases tend to develop with the new web technologies using the web languages html5 and javascript. Interactive web pages are integrated in order to explain the diseases with arrows, coloring and text. 3D Images are constructed from series of images, to show the volumes of organs or tumors. Simulated medical images are created to verify and compare the algorithms working with the contrast levels in calibrated uptakes.

All these medical image databases are shared through the internet using the security of a password which is delivered in most of the cases by the administrator of the database.

The image databases aiming research communities stay very simple, the choice of the series of images is proposed through tables sometimes without the possibility to see the image without downloading, whereas the databases with educational purposes adopt frames with many colours, a selection of buttons with e-cases, explanation texts, history of the patients and associated images. So, we can conclude saying that the typology of medical image databases is mostly related to the targeted public and tends to be multimodal because diseases show up in different modalities and the information is complementary.

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