A Web-Based System for Biomedical Image Storage, Annotation, Content-Based Retrieval and Exploration


October 14, 2009
Outline

1. Introduction
2. Image Collection
3. Interaction
4. The System
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Why is it important an online histology atlas?

- All animal organisms are composed of the four fundamental tissues
- A large and complete atlas of histology is useful to study tissues
- It is essential in histology research since it helps to investigate problems in cell biology, molecular biology, genetics, animal and human behavior.
- Support to learning and training of new practitiones in Tissue Engineering and in vitro studies.
A digital and complete atlas avoid to repeat tissue acquisition and processing.

Preserves material that may decrease its quality over the time.

Costs reduction

Undergraduate and postgraduate programmes supported by advanced collection references.

Virtual labs for teachers in histology, pathology, cytology and physiology lectures.
Supporting Research

Research

Center of Cell Biology (Biophysics and Biology of Membrane), Supported by: Centro Internacional de Física and Universidad Nacional de Colombia, Sede Bogota.

Research fields:
- Tridimensional cell culture
- Membrane properties in the Leishmania-macrófago model and other models
Application Case: Supporting Research

Applications

- Nerve regeneration: In vitro culture of peripheral nerve component cells
- Thyroid function: Functional thyroid follicles
- Parasite-host cell relationship: Impact of Leishmania infection on the three membrane system found between the parasite and its host cell, the macrophage

- This research line is based on the rationale that tridimensional in vitro culture provides models where tissue function can be explored.
- Nerve section is a condition that can result from an important number of causes.
- The normal regenerative response of the nerve can be improved by the use of different component chambers, such as those that include normal cell components of the nerve are promising.
Thyroid function
[Cabezas 2005, Cabezas and Spinel 2005]

- Thyroid pathology such as hypothyroidism, endemic goiter and cancer of thyroid are common in Colombia and other countries.
- Understanding aspects related with hormone synthesis or iodine transport will be important to determine the impact of these pathologies on thyroid function.
Parasite-host cell relationship

- Leishmania spp. infect 15 million people in the tropics, including Colombia, and the resulting disease is increasing due to environmental changes, drug resistance and HIV/AIDS.
- Leishmania species are, obligate intracellular parasites of the macrophage-dendritic cell lineage.
- Understand the response and changes of macrophages is an important factor to design potential therapeutic targets.
A Web-Based System for Biomedical Image Storage, Annotation,
12 mice were used ICR strain, 20-30 g (young adult) acquired in the Experimental Animal Lab of the Faculty of Veterinary and Animal Science, National University of Colombia in Bogotá for the different organs.

Special tissues as the flat surface epithelium was obtained from stratified keratinized human skin and urine epithelial tissue of cat were kindly donated by the laboratory pathologist at the National University of Colombia.
Figure: Mice used to extract tissues samples.
Tissue samples were fixed in 200 paraffin blocks.
From the blocks, 300 slides were mounted and digitized at 20,000 images.
The image collection is of histology to the study of the four fundamental living being tissues (connective, epithelial, muscular, nervous).
Examples of fundamental tissues

Figure: Examples of four fundamental tissues
Basall-Cell Carcinoma

- The most common skin disease in white populations due to ultraviolet radiation exposure
- Pathologists perform visual analysis to understand cell structures
- The collection is composed of 5,995 images at $1,280 \times 1,024$ pixels, acquired under a Nikon microscope at the Pathology Lab
- A subset of 1,502 images was studied and annotated by a pathologist
- It was defined a list of 30 visual structures associated to tissue and cell properties
- 18 main concepts associated to basal-cell carcinoma images
Basall-Cell carcinoma

Image example (nodules, palisaded cells and cleft)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilosebaceous annexa</td>
<td>145</td>
</tr>
<tr>
<td>Cystic change</td>
<td>67</td>
</tr>
<tr>
<td>Elastosis</td>
<td>125</td>
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<td>Eccrine glands</td>
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<tr>
<td>Lymphocyte infiltrate</td>
<td>140</td>
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<td>Perineural invasion</td>
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<tr>
<td>Lesion with fibrosis</td>
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<td>Micronodules</td>
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<tr>
<td>Necrosis</td>
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<tr>
<td>N-P-C, elastosis</td>
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<tr>
<td>N-P-C, fibrosis</td>
<td>50</td>
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<tr>
<td>N-P-C, infiltrate</td>
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<tr>
<td>N-P-C, pilosebaceous annexa</td>
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<tr>
<td>N-P-C, trabeculae</td>
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<tr>
<td>Morpheaform pattern</td>
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<tr>
<td>Rod trabeculae</td>
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<tr>
<td>Ulceration</td>
<td>15</td>
</tr>
<tr>
<td>Sanguineous vessel</td>
<td>122</td>
</tr>
</tbody>
</table>
Basall-Cell carcinoma

- This collection is useful to support the decision making process of new similar cases.
- Medical practice is based on personal experience and on learning of others’ experience.
- The opinion of an expert is better considered, when it is based on a large experiential evidence of its own or of other experts [Tonelli 2001].
- With this kind of tools it is possible to deliver the required information at the right time, in the right place, to the right persons to support quality and efficiency in the health-care practice.
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A Web-Based System for Biomedical Image Storage, Annotation,
Interaction

- Users need a flexible tool to **interact** with the information in the collection.
- Interaction means being able to **send** data and also to **obtain** data.
Being aware of the image collection structure and all the details in it:

- A very hard task when the information in the image collection grows
- Different users adding information in a collaborative way

BiMed: An information technology designed to assist in this task
Adding Information

- Adding more images?
  - Upload new images
  - Organize collections

- Attaching descriptions or metadata?
  - Add text annotations
  - Sketch regions of interest
Searching Information

- I remember some of the text annotations... How do I search?
  - Use a text search box
  - Look in the ontology menus and directory structures

- I find this image quite interesting... Are there more images like this?
  - Use its text descriptions to search related images
  - Use the "Similar Images" option to search using the visual similarity tool.
Not quite sure about what I want... I would like to take an overview of the image collection...

- 2D Visualizations of the image collection are available.
- Summarizations of the image collection
- Feedback and interaction to discover new information
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A Web-Based System for Biomedical Image Storage, Annotation,
Image annotator

- Allows to attach global image descriptions and to draw regions of interest using polygons
- A region of interest can have also additional text annotations
- A Histology thesaurus was defined to annotate regions. Free text annotation are also allowed
- All the 20,000 images have been globally annotated
- So far, 605 images have been annotated with 1622 regions of interest
Figure: Image annotator interface used to describe the image content and regions of interest.
Text search

- Text annotations are indexed using information retrieval techniques
- Search by specific terms of histology domain with spell-checker
- Contribute to understand different examples with specific concept
Figure: A textbox is used to search by text. The results are images with the same text in global annotation or in region annotation.
Content-based image search

- Search similar images using visual features
- Global features describe the image content using the histogram distribution of color, edges and texture
- It is important to find similar tissues in appearance for train biologist, physicians, etc.
- Help to understand the normal tissue appearance for controls samples in biological research
Figure: User interface to search similar images and results by visual features.
Global visualization of an image set of collection help to explore the whole image collection.

A simple 2D visualization summarize the image collection by a visual feature.

In medical domain exist not this kind of tools to explore large biomedical images data.
Figure: 2D Visualization of muscle tissue by similar images result using texture feature.
System Architecture

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Future Functionalities

- Security, authorization, authentication and roles
- Distributed environment
- Support to standard communication protocols (HL7, DICOM) and standard image formats (JPEG, DICOM, PNG, GIF, DICOM-DIR, JPEG2000)
- Data streaming and cache support
- Extensible platform (services and plugins)
- Workflow (telemedicine and health centers)
- Automatic annotation
- 3D image reconstruction
- New visualization functionalities (mega images, access to different quality levels, zoom and pane, etc.)
- New image edition functionalities
References


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