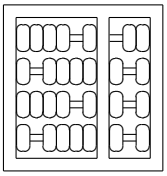

INSTITUTO DE COMPUTAÇÃO
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Evaluation of a Tablet PC image annotation and retrieval tool in the parasitology domain

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Abstract

The project Deployment and Assessment of an Image Annotation and Retrieval Tool has the objective of specifying and implementing an application for image support annotation and search (based on a textual and a visual description) in the biodiversity domain. This technical report presents the activities related to the use of the tablet PC tool in the parasitology domain at Unicamp. The objective of this tool is to help the comparison of morphological characteristics among different species. The report is divided into activities accomplished, application setup and specific features, followed by experimental results and conclusion. Preliminary results showed that students regarded the tool as being very useful, contributing as an alternative learning approach.

1 Introduction

The project Deployment and Assessment of an Image Annotation and Retrieval Tool, Including Biodiversity, is a joint collaboration between the Institute of Computing at Unicamp and Virginia Polytechnic Institute and State University, USA. The main objective of this project is the specification and implementation of an application for image support annotation and search (based on textual and visual description) in the biodiversity domain.

The image annotation and retrieval tool aims to help scholars work with images and parts of images; associate them with multimedia information like text annotations, derived from annotations made by an electronic pen on a tablet PC; and, later, retrieve information based on text- and content-based retrieval techniques. Information may be retrieved through searching (on text and image content), as well as browsing by key or taxonomy. We believe that the tablet PC image annotation and retrieval tool will increase the educational value

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of the tablet PC by enhancing and enabling many diverse courses involving use of images and annotations. Henceforth, we will refer to the tablet PC image annotation and retrieval tool as the tablet PC tool.

The evaluation of the tablet PC tool considered two different scenarios. The first experiments were conducted at Virginia Tech [2]. The objective was to investigate the use of the tool as an additional approach to fish species identification. The usual approach was using dichotomous keys (a series of questions about morphological features of a specimen) to identify species. The second set of experiments was conducted at Unicamp. The objective was to evaluate the use of the tablet PC tool in tasks comparing morphological characteristics of different parasite species. The comparison of species is important in parasitology because details like shapes (such as round or stick), forms (such as pregnant or mature), number of teeth, etc., are decisive to their classification.

This document presents a report about the activities related to the use of tablet PC tool in the parasitology domain during the second semester of 2008 at Unicamp. The activities were accomplished by a computer science team (Ricardo Torres, Nádia Kozievitch, Felipe Andrade, Thiago Falcão, and Evandro Ramos), a parasitology team (Silmara Marques Allegretti, Marlene Tiduko Ueta and Rubens Riscala Madi), and volunteers from the Biology Department.

This document has the following organization: section 2 presents an overview of the tablet PC tool; section 3 shows a specific scenario for the parasitology domain; section 4 lists accomplished activities; section 5 describes the application setup for the parasitology domain; descriptions of experiments and preliminary results are detailed in section 6; and section 7 presents the conclusions and a discussion of future work.

2 Overview of the tablet PC tool

The tablet PC tool combines text- and content-based image description and retrieval, where the objective is to enhance important educational activities that involve working with specific contextualized information and sharing information among teachers and students, through the use of pen-based computing, annotation, and content-based image retrieval. Please check http://si.dlib.vt.edu/ for further details on the project.

With the tool, users can:

- Use the pen-writing capability of tablet PCs to:
    1. Create marks on images.
    2. Write annotations and associate them with marks and images.
- Link text annotations with image marks.
- Browse and search marks and associated data, using text- and content-based retrieval mechanisms.

The tablet PC tool has four menu options: annotation (as show in Figure 1), search by image, search by text, and browsing. At the annotation menu option, after choosing

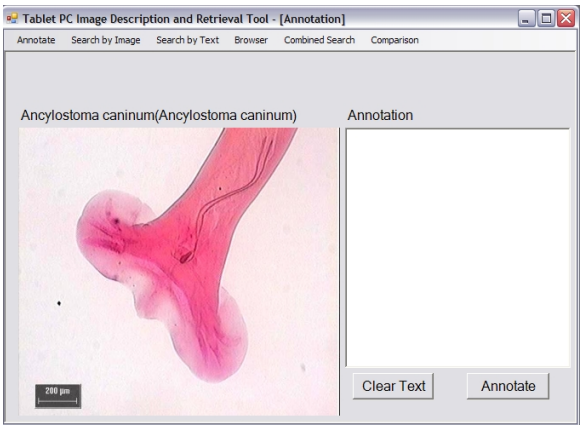

Figure 1: Annotation tab.

an image, it is possible to associate a text with a specific region within the image. If the user wants to search for images similar to a given input, he can use the search-by-image menu option. If the objective is to look for specific words within the species metadata, the search-by-text menu option should be used, as shown in Figure 2. The browse menu option supports navigation by taxonomy (family, genus, and species name) and by dichotomous key.

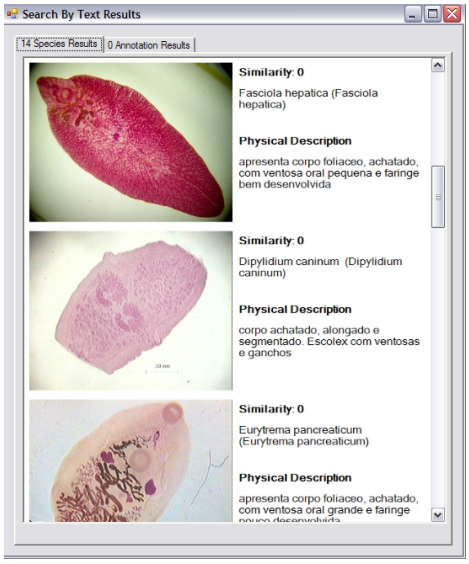

Figure 2: Search results at the menu option search-by-text.

The main interface was developed using .Net C# language. The content-based image search component is a Dynamic-Link Library (DLL) written in C#, resulting in a flexible and portable application under the technology perspective [3].

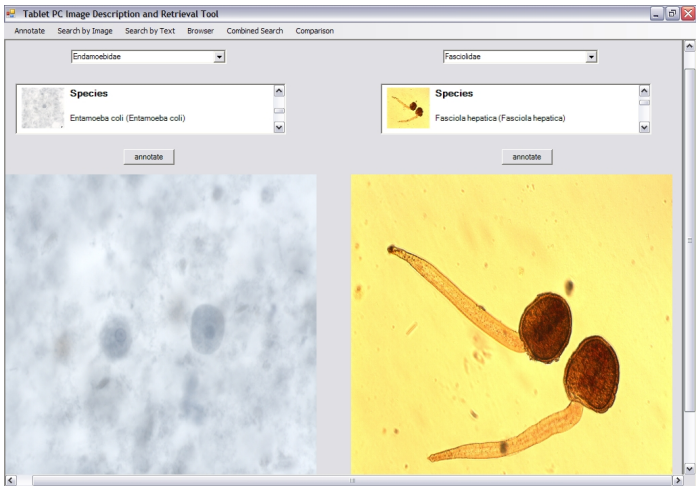

Figure 3: Species Comparison Tab.

Figure 4: Annotations example.

3 Scenario

Sandra is enrolled in the Zooparasitology class, and just started learning about different parasite species. She already had several classes with a microscope to analyze specimen details, but she still has to summarize which morphological characteristics are important in each parasite phase. These morphological characteristics are relevant to distinguish different species.

Sandra walks through the comparison menu option in the tablet PC tool, first selecting families *Endamoebidae* and *Fasciolidae*. Then she selects species *Entamoeba coli* and *Fasciola hepatica*, as shown in Figure 3. Then she creates annotations about each specimen, summarizing key characteristics, as shown in Figure 4.

In the last phase, she is able to annotate geographic information about *Entamoeba coli* and *Fasciola hepatica*. She may identify, for example, in which regions we can find both species.

4 Overview of activities accomplished

For the parasitology domain, new functionalities were developed. The first was the adaptation of the database schema to the new needs. New data about parasite species (textual and image data) where loaded into the database. All the parasite images had different sizes and were obtained at different resolutions. We had to adapt the tool to support images with different zoom levels. The third functionality was the creation of a species comparison tab, on which it is possible to load two different parasite images for a visual comparison and annotation. The last functionality was the integration of the application with geography-based services which support annotation and location of species on maps.

We conducted two experiment sessions involving students of BP680 - Zooparasitology, offered by the Biology Department. The objectives of these experiments were to validate the tablet PC tool in the new domain as an alternative method to teach concepts related to parasites using annotations.

For conducting the experiment with the Zooparasitology students, we completed the following activities:

- submission of a project to the "Comitê de Ética e Pesquisa - FCM -Unicamp", requesting formal permission to UNICAMP to conduct experiments related to the use of the tablet PC tool;
- description of an experiment and application validation plan for the semester;
- creation of a Portuguese-language manual for the application;
- adaptation and Portuguese translation of the initial and final questionnaires;
- adaptation and extension of the tablet PC tool for dealing with data for parasites. The previous application was developed for the Ichthyology domain.

The first step for starting the project was a formal request to Unicamp for our research with tablet PCs and students. The following documentation was prepared, based on the official URL site (http://www.fcm.unicamp.br/pesquisa/etica.php):

- Complete the document for CONEP (Comissão Nacional de Ética em Pesquisa - available at http://www.saude.gov.br/sisnep), with details about how the research could impact the students;
- Write a project, including the ethical aspects of the research;
- Write a form requesting the consent of the students to work as volunteers;
- Present a detailed description of the project budget;
- Complete the biographical sketches of the participants.

The documentation was submitted to a committee and, after providing additional documentation, the project was approved.

We created four questionnaires, later adapted and translated into Portuguese language. Two initial ones were used before starting the class, and two final ones were given at the end of the class. The opening questionnaires verified the familiarity with computers, English language and tablet PCs.

There were two experiment sessions with students of BP680 - Zooparasitology, offered by the Biology Department, using the tablet PC laboratory at Unicamp. At the first session, students were introduced to the tablet PC tool. All functionalities were tested using a Portuguese manual, and at the last phase, students were able to insert annotations for two different species. We presented questionnaires to the students for evaluating general knowledge and verifying how useful the application was.

In the second experiment, the comparison menu option was updated, and students were able to select two species and to annotate them separately. This feature was included because professors identified it as an important way to visualize different images at the same time while annotations are being made. We presented two questionnaires to the students, an opening questionnaire for evaluating general knowledge regarding species comparison and a final one, verifying how useful the application was.

Since the students had not worked with either the tablet PCs or the tablet PC tool for annotation, a Portuguese manual was created, explaining each functionality with image examples. Figure 5 shows the taxonomic navigation figure in the Portuguese manual. If you click on the *Taenidae* family, for example, the *Taenia* genus could have a breakdown to *Taenia saginata* and *Taenia solium* species. If you click on the species name (a blue link at the right bottom), the application would show a new menu option with details about the species. Figure 6 shows the tree-view navigation available in the Portuguese manual.

Several meetings were necessary to understand some of the main concepts of the parasitology domain and to identify how the application could help the students and professors. For example, the necessity of storing different information for each life history phase: as an adult, the shape, characteristics and figures can be different from these in other phases. For each phase, there were images obtained at different resolutions.

Preliminary results showed that students would like to use the application again, and identified it as very useful, contributing as an alternative learning approach.

5 Application setup for the parasitology domain

The first setup in the application was the database adaptation, followed by the application tailoring to different image zoom levels, the comparison menu option and the geography-based annotation service.

5.1 The database adaptation

The database adaptation was necessary since the new parasite data did not fit the available database schema. The previous version of the application was tailored to fish images (all had similar shapes and figure sizes, with constant colors) for the ichthyology domain. Parasites have different shapes (such as round or stick), forms (such as pregnant or mature), colors (depending on which substance was used with the specimens), and their images can have

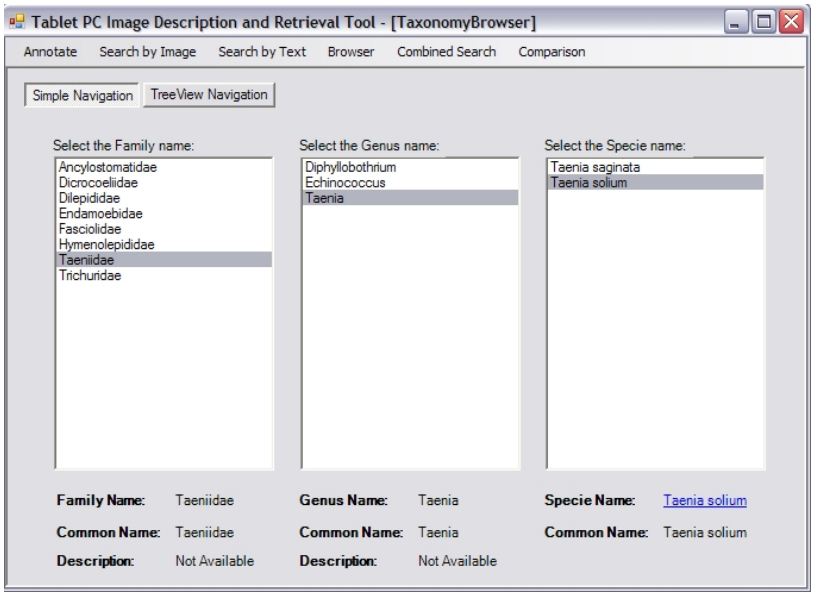

Figure 5: Taxonomic navigation explanation figure from the Portuguese manual.

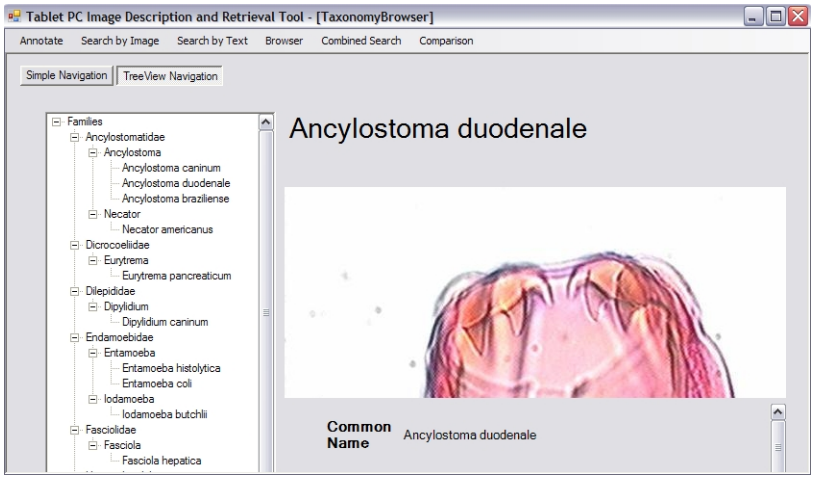

Figure 6: Tree view navigation explanation figure from the Portuguese manual.

different scales. These issues resulted in need for database adaptation in terms of metadata and schema.

5.2 Application tailoring to the different image zoom levels

The tablet PC tool was adapted to different sizes of images for better visualization, since their sizes varied between 33 kb and 948 kb. Their color and shape exhibited variations when compared with each other, as shown on Figure 7. For identifying the *Ancylostoma caninum* species, for example, only a figure of their head was needed (figures with with pink

or red color). If the context was changed to *Entamoeba histolytica* species, shapes changed to oval or round, identifying cysts (with figures in gray color).

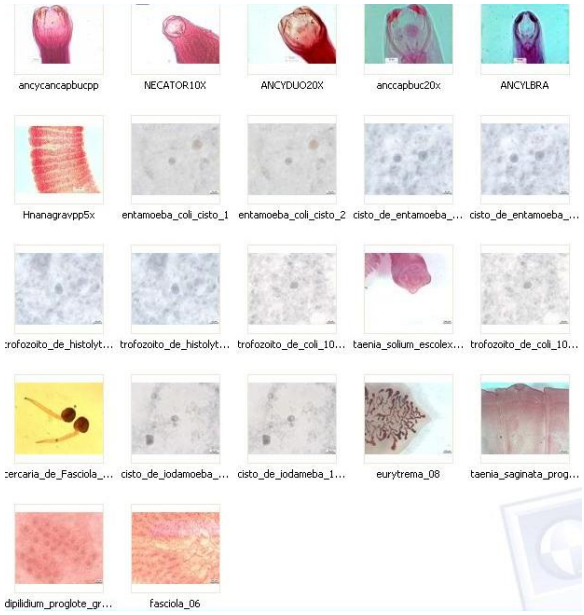

Figure 7: Example of parasite images used in the first experiment session.

5.3 Comparison Tab

A new menu option was created for species comparison where two images can be visualized at the same time. The objective of the comparison menu option is to enable a visual comparison of images, on which students can make several annotations to describe their morphological characteristics (similarities and differences).

5.4 Geography-based annotation service

The main objective of this feature is to allow the user to create geographic annotation for the species (like marks associated to points, lines and polygons (regions)); enable geographic navigation, using maps which allow scrolling and zooming; enable marks like points, lines and regions associated with text/multimedia information; enable ability to detail maps and make marks; and finally, support the association of universal units for positions of marks in the map (using latitude/longitude). These annotations can be combined with the other content types, providing optimized searches and better conditions to analyze the scenarios of study based on geographic information.

Using this new feature, researchers, for example, are able to store information about species habitat during a field study and associate these data to species.

5.4.1 Developed Tool

The tool is a web-based system that accesses the same database and application base of the tablet PC project. There is a single page containing a Taxonomy Navigation, used to select a species, and a map interface, used to to create the annotations.

Figure 8 shows the Taxonomy Navigation for geography-based annotation. Three lists are used to display the taxonomy tree: Families as root, followed by Genus and Species. Lists are loaded dynamically. When a species is selected, the geographic annotations are displayed in the last list.

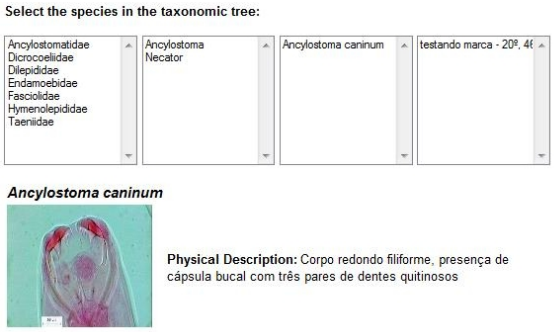

Figure 8: Interface used to select species for geographic-based annotation (Taxonomy Browser).

Figure 9 shows the map interface. This interface is used to create and display the geographic annotations. The letters are used to indicate the controls in the picture:

- at "A", there is the map. Each position on it corresponds to a geographic coordinate (latitude and longitude);
- behind "B", there is the mode selector, used to change map visualization between political division, satellite and hybrid modes;
- at "C", there are the navigation controls (the user can navigate by clicking and moving the mouse);
- at "D", the latitude and longitude of the center of the map are displayed;
- at "E", the buttons to enable/disable the creation of new marks;
- and at "F", the button 'Go to Location' is used to center the map on the latitude and longitude in the controls at "D", when they are edited.

After selecting a species, the user can create marks on the map, pressing the buttons at "E" and clicking on the map. Figure 10 shows a user creating a mark, with title and description.

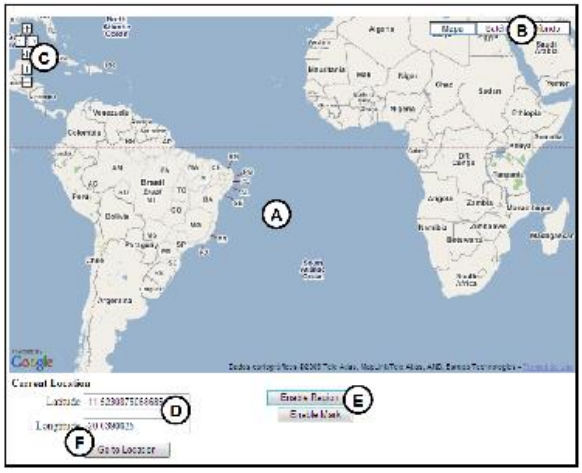

Figure 9: Interface used to create and display geographic annotations.

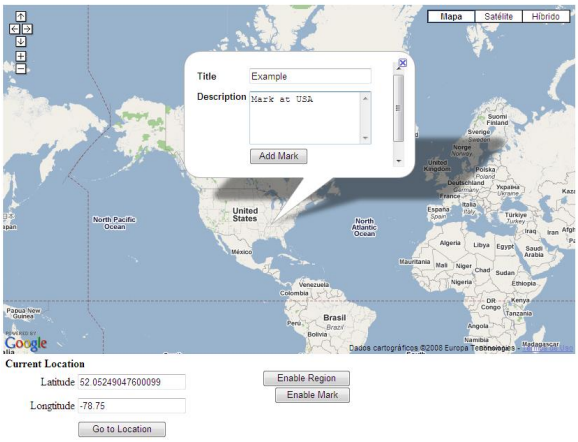

Figure 10: User creating a geographic annotation.

Marks are stored in HTML format, and are displayed on the map. This format permits rich formatting of the annotations and adding of multimedia content (audio, video and image). Figure 11 shows a mark displayed on the map.

Lines and regions can be annotated on the map, in order to determine coverage areas of species, rivers and other kinds of objects. Figure 12 illustrates a selected region annotated on the map, at a specific latitude and longitude.

5.4.2 Technologies Used

The geographic feature was developed using Microsoft .Net Framework 3.5. The maps and the navigation functionalities are part of Google Maps API [1], developed in JavaScript. This Google service provides detailed maps and lets the user navigate using the mouse

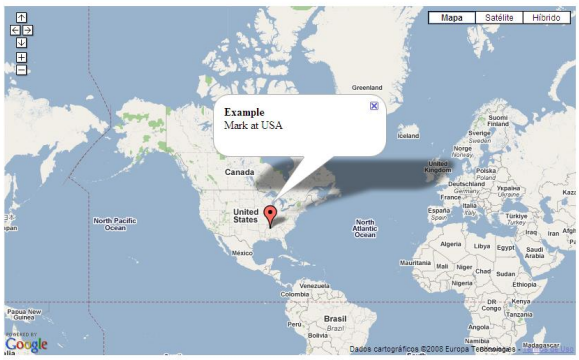

Figure 11: Mark with title and description displayed on the map.

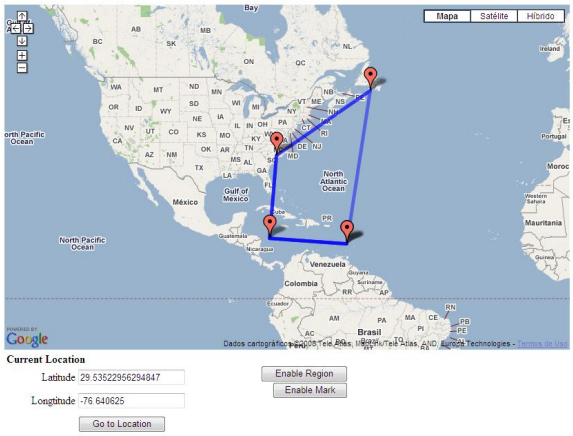

Figure 12: Region annotated on the map.

pointer. To work with a client-side script to control the map requires that the posts sent by the user browser do not refresh the page; otherwise, the information loaded on the map would be lost or need an update from the server. The Ajax technology is used to avoid these refreshes. A specialized component is used to integrate the Ajax requests with the framework.

6 Experiments

Experiments were conducted to validate the use of the tablet PC tool within the parasitology domain. The Zooparasitology class ran for about 5 months. They already had practiced the species comparison using paper and writing the physical characteristics. However, they had never worked with a digital application or used a tablet PC. The students were in the second month of classes when the tool was introduced to them. Since there was a small number of students, it was possible to allocate a tablet PC to each student. There were two approaches with students of BP680 (Zooparasitology). To participate in the project,

it was necessary that the student was enrolled in BP680 and signed the consent form. We used the following materials:

- Tablet PC tool,
- Tablet PC tool user manual,
- Parasite species identification key guidebook/sheet,
- Entry and exit questionnaires, and
- Consent form.

6.1 Summary of the first experiment session

The first experiment session had 13 volunteers from the Biology course, using 22 parasite images, from the following species: *Ancylostoma caninum, Ancylostoma duodenale, Ancylostoma braziliense, Fasciola hepatica, Entamoeba histolytica, Iodamoeba butchlii, Dipylidium caninum, Entamoeba coli, Eurytrema pancreaticum, Hymenolepis nana, Necator americanus, Taenia saginata* and *Taenia solium.*

The experiment session was divided into three phases. We introduced students to the tablet PC tool. All functionalities were tested using a manual. Finally, students made annotations for two different species.

We presented two questionnaires to the students. The first questionnaire verified familiarity with computers, English language, and tablet PCs. The second questionnaire verified how useful the application was.

Thirteen students completed and returned the initial and final questionnaires for the first experiment session. Nine out of the thirteen students considered themselves as having medium or high knowledge of computer, but eight had never worked with a tablet PC before. Students had already used annotations, but only with paper, scientific publications, and printed figures. No application known by the students allowed digital annotation, comparison or identification. Literature, papers, microscope analysis and bibliography identification key were the most-used sources for identifying and comparing species.

Twelve out of the thirteen students considered the tablet PC tool very useful for species identification, contributing to annotation and comparison. Students liked to work with taxonomic navigation and the interaction with the tablet PC pen was considered easy.

6.2 Summary of the second experiment session

The second experiment session had 12 volunteers from the Biology course, using 76 parasite images, as shown in Figure 13. More images from the same species with different zoom levels were used this time, with 17 species: *Ancylostoma caninum, Ancylostoma duodenale, Ancylostoma braziliense, Fasciola hepatica, Entamoeba histolytica, Iodamoeba butchlii, Dipylidium caninum, Entamoeba coli, Eurytrema pancreaticum, Hymenolepis nana, Necator americanus, Taenia saginata, Taenia solium, Diphyllobothrium latum, Echinococcus granulosus, Hymenolepis diminuta,* and *Trichuris trichiura.*

Figure 13: Parasite images used in the second experiment session.

The comparison menu option was updated, and students were able to select two species and make separate annotations for each one, as shown in Figure 14. This feature was included because teachers identified it as an important way to visualize different images at the same time while annotations were made.

The main task in the second experiment session was comparison between *Nematoda* and *Cestoda* classes, as shown in Figure 15. The objective was to verify the usefulness of the comparison function. Images from *Taenia solium, Hymenolepis nana, Ancylostoma duodenale, Ancylostoma braziliense* were annotated in different regions. For some species, there was more than one image (one species could have several images with different forms), with

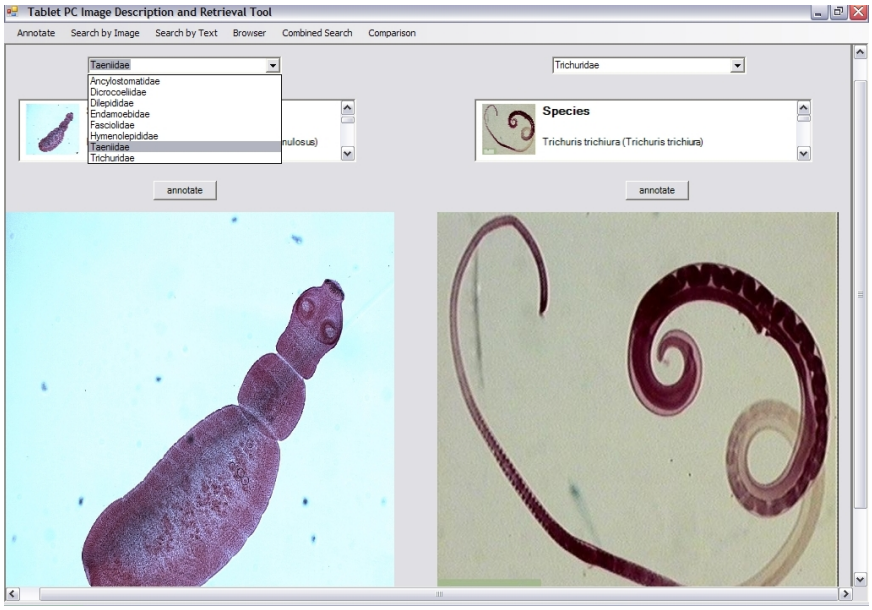

Figure 14: Comparison menu option enabling annotations in two different images

different zoom levels, enabling students to identify different morphologic characteristics.

Twelve students completed and returned both initial and final questionnaires from the second experiment session. The main functionalities used by students were comparison, annotation, and browsing. All students stated that they would like to use the application again. Answers to the questionnaire indicated that the traditional comparison method leads to more correct answers than the one with the tablet PC tool. According to students, the traditional method is better because:

- the tablet PC tool had few species,
- the application had few images for each species,
- the students were not familiar with the tablet PC, and
- the tablet pc recognized only English words.

Still, eleven of the twelve students stated that the tablet PC tool is very useful as an alternative approach for teaching, as shown in Figure 16. Students feedback stated that annotation, taxonomic navigation and comparison tabs as preferred features. Some of the comments about the tablet PC tool are listed below:

- “I would really like to work with it again.“
- “The application could have more interactivity with species descriptions, not only with morphology, but biology characteristics, for example.“
- “A very good approach for species identification and comparison.“

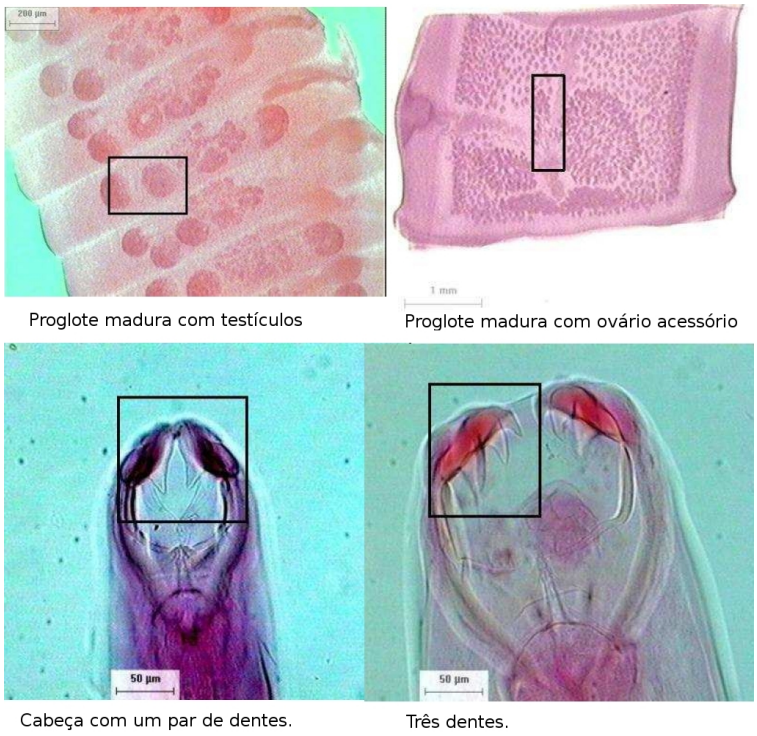

Figure 15: Examples of annotations made by students.

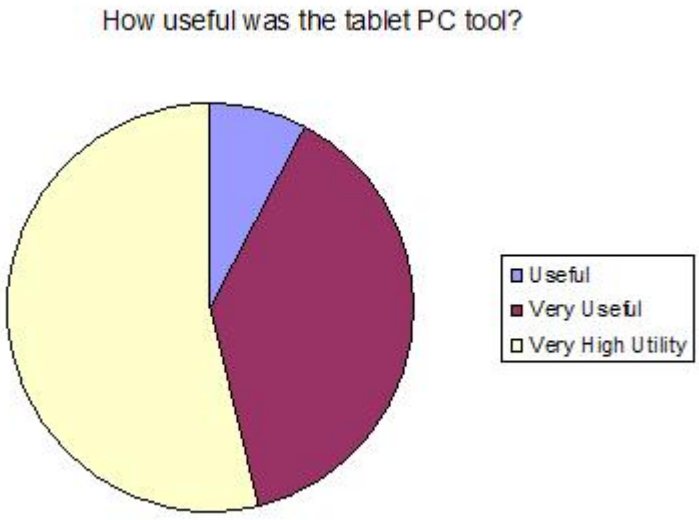

Figure 16: How useful was the tablet PC tool for the students.

7 Conclusion

We present a report about activities related to use of tablet PC tool in the parasitology domain during the second semester of 2008 at Unicamp. This tool was a prototype to explore the integration of the tablet PC technology and biology, exploring parts of images and their integration with annotations. The students approved it as an alternative approach for learning parasitology.

The partnership with the Parasitology Department of Unicamp contributed to knowledge exchange between different domains. For the biology students, it was necessary to learn a different technology and new concepts, and for the computer science team it was necessary to understand a new context for image and annotations. The partnership with Virginia Tech contributed by exchanging experiences, resulting in a more flexible, portable and stable application.

Future work includes enabling the Portuguese language by the tablet PC pen; a centralization of data from the different users into a unique database; link marks to other multimedia information, such audio/video records; addition of more parasite data to the database; and the creation of an application installer.

8 Acknowledgments

We would like to thank the Parasitology Department, the tablet PC laboratory at Unicamp (Prof. Rodolfo Jardim de Azevedo and his team), and the students from BP680. We would also like to thank CAPES, FAPESP e CNPq - BioCORE Project, HP Technology for Teaching, and Microsoft Research.

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