A Federation Enabled Virtual Microscope

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1. EXECUTIVE SUMMARY

The coming European Higher Education Area (a.k.a. Bologna Process) will reduce the current learning model with a high level presence lecturing in favor of a model with a higher requirement for personal learning from the students. This requires new tools and learning models.

1.1.Background

The present paper will introduce a tool that has been developed for remote study of tissue images. This tool eliminates the, otherwise unfeasible, need for the students to own a microscope and a collection of tissue preparations. Moreover, this tool is not limited to optical images, as a student's personal microscope would be, but also allows for electron microscope images, confocal images, and other types of images that can be produced with very expensive equipment.

The knowledge acquired in the Central IT service about remote and collaborative learning while developing other tools and infrastructures - like the ones presented on another paper by one of this paper authors - has been central to the development of this tool. This has allowed us to use advanced Identity Management technologies for controlling access to the tool and the different image collections. The tool can be integrated into an Identity Federation and obtain the access rights from the user's Identity Provider, thus reducing the need for user management at the tool site. This results, also, in better management and allocation of physical resources, like the image producing equipment or the storage facilities, as they can be distributed across participating institutions.

1.2.Conclusions

The tool can be used from a web browser requiring no special add ons, not even Java.

There are several key differentiating points to this tool:

- Easy integration into an Identity Infrastructure for collaborating applications
- Completely based on Open Source components
- Powerful browser based user interface
- Image directory indexing system based hierarchical classification codes

The initial version of the tool is focused mainly on optical microscopy histological imaging, as it was the requirement that launched the project, but future development will also include images produced with diverse micro and macroscopic technologies.

2. INTRODUCTION

The coming European Higher Education Area (also known as Bologna Process) will reduce the current learning model with a high level presence lecturing in favor of a model with a higher requirement for personal learning from the students.

The present system dictates that teaching departments specify the number of credits a subject contributes to the curriculum. This translates simply into hours a student should sit in a classroom listening to a teacher, so to say.

The new interpretation of credits brought by the European Higher Education Area require a paradigm shift in teaching, and learning, methods. The new credits not only specify the number of hours a student has to spend in classes listening to lectures, but also the time they have to spend doing personal learning like home assignments or library research. This translates into a more personalized way of learning that requires new methods and tools.

The reasoning above made the department of cell biology in the University of Málaga to approach the ICT services with the idea of using a collection of high quality microscopy images for doing on line teaching. The availability of such tool in the University infrastructure would allow the students to review the material at heir own pace and in their own time, outside the class room, without the need to own any physical equipment.

Thus, we have developed one of such tools, in the virtual world, that can comfortably substitute a classical tool from the physical world, and even improve on it.

3. OBJECTIVES

The technical design and implementation team studied the available options and found that there where several tools with different handicaps:

- Proprietary image server and viewer
- Thick clients, either stand alone or implemented as Java applets
- Crude user interface
- Scarce options

This prompted us to decide for our own design with a list of key requirements:

- Open source tools for all system pieces
- Browser based user interface with no heavy downloads
- Identity centered with federation capabilities
- Improve on the classical microscope paradigm

4. DESIGN

4.1.User experience

It is not really possible to fully map the user experience of using a real microscope onto a computer screen controlled by mouse and keyboard. So, we decided to take a liberal approach to the concept of simulated microscope, adding some interesting features:

- Simplified image selection and retrieval
- Two image mixing, e.g.: combining two differently dyed slices of the same specimen
- Image annotation, both teacher and student personal annotations
- Easy access everywhere
- Images not limited to low magnification optical ones

4.2.Identity and Access Management

The notion of user, local to the application, cannot be totally avoided, although there are several levels for that, from complete user creation in an application database provisioning form user identity information gathered from the security assertion through a mere user identifier that uniquely identifies a person.

The full provisioning approach successfully employed by the Czech pathology atlas supported our initial idea that we should pursue a fully federated approach. Such mechanism allows the tool academic administrators (i.e: teachers) to specify entitlements the users should have in their assertions to access the images.

The federated approach also allows for collaboration amongst institutions that can share the costs of producing the images, then sharing their instances of the tool in the federation.

Also, the federation capabilities allow this tool to become part of an identity centered application cluster.

4.3.Image storage, serving and classification

The high quality of the images, needed to resemble a real microscope, makes them heavy weights in terms of both storage space and bandwidth. Serving this huge files in full to the client is neither feasible nor advisable, but there are solutions readily available for transforming the needed areas to lighter jpeg files. This also allow for the use of high quality high definition images protected by intellectual property, as they will never be sent in full to the client.

Uploading such big files, although possible, is not advisable, Our approach is to recommend that the files be loaded into the server storage, using some local method, to a staging area controlled by the teachers, who can then use the administration interface to fill in the metadata about the images and move them into the appropriate collection. And assing access permissions.

We have gone beyond the usual single hierarchy classification, allowing the images to belong into as many hierarchies as the teachers see fit, through the use us of RedIRIS COPA codes for tagging the images metadata.

Teachers also have some extra tools when using the microscope interface, that allow them to make annotations that will be layered over the images when students view them.

5. TOOLS

5.1.Web application framework

Django is a high-level python web framework that encourages rapid development and clean, pragmatic design. The ICT experience using this tool confirms that this is true. So, selecting Django for the web server side of our application came as a natural decision for us.

This application answers the requests from the user interface running on the user's browser and relays the appropriate commands to the image server. It also applies the access controls and provides the administrative interface for image classification, access controls and other tasks.

Django maps the user entitlements received in the assertion to internal profiles (i.e.: groups in Django parlance) for enforcing and managing the access controls.

5.2.Federation

We have a wide experience about advanced Identity Management so everything we are developing is being included in our “identity enabled application cluster” so that the university community can easily access any part of it, if the needed conditions are met.

The application is protected by a SAML 2.0 SP (Service Provider) implemented in SimpleSAMLphp and connected to the Django framework through a common middleware. This means that connecting the tool to an identity federation is a matter of adding the appropriate metadata to the SP configuration.

5.3.Images

Images are the real heart of a microscopy application. The most widely used image format for the kind of application we have developed is tiled pyramidal tiff.

Each of this files contain several images of the same object (e.g.: a tissue preparation) at different levels of magnification. Each image is divided into tiles (or squares). This allows for light and somewhat fast viewing of otherwise very heavy images, as they are not transfered in full, with no loss of quality at the same time.

The image server transforms the requested tiles into jpeg files that are sent to the client. Each of them is identified by the level of magnification and a 2 dimensional coordinate in the plane of the corresponding image.

We have selected IIPImage, an open source light-weight streaming client-server system for web-based viewing and zooming of ultra high-resolution images, as the backend image server.

The front end is an Apache web server with the Django based application running on top of it.

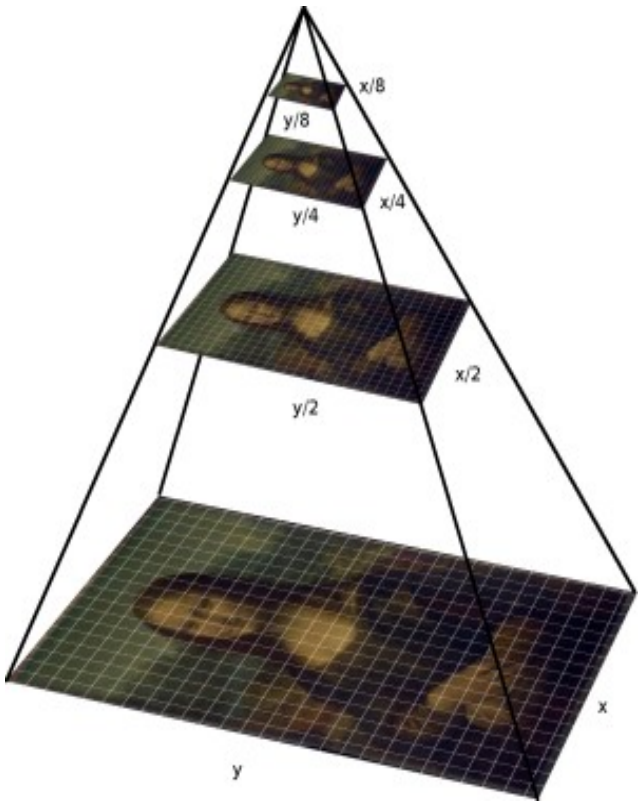

Image 1

Pyramidal tiled TIFF

5.4.User interface

The user interface is built around a javascript application based on the JQuery library. This communicates to the web server based Django application using Ajax. We have taken ideas from the National Gallery IIPimage viewer, mostly the capability of mixing two images of the same object taken with different technologies (or using different dyes).

The applications controls try to mimic those on a real microscope, so the user has to use a similar mind set as when using a real instrument.

The user interface also allows for image search and selection, for loading onto the tool.

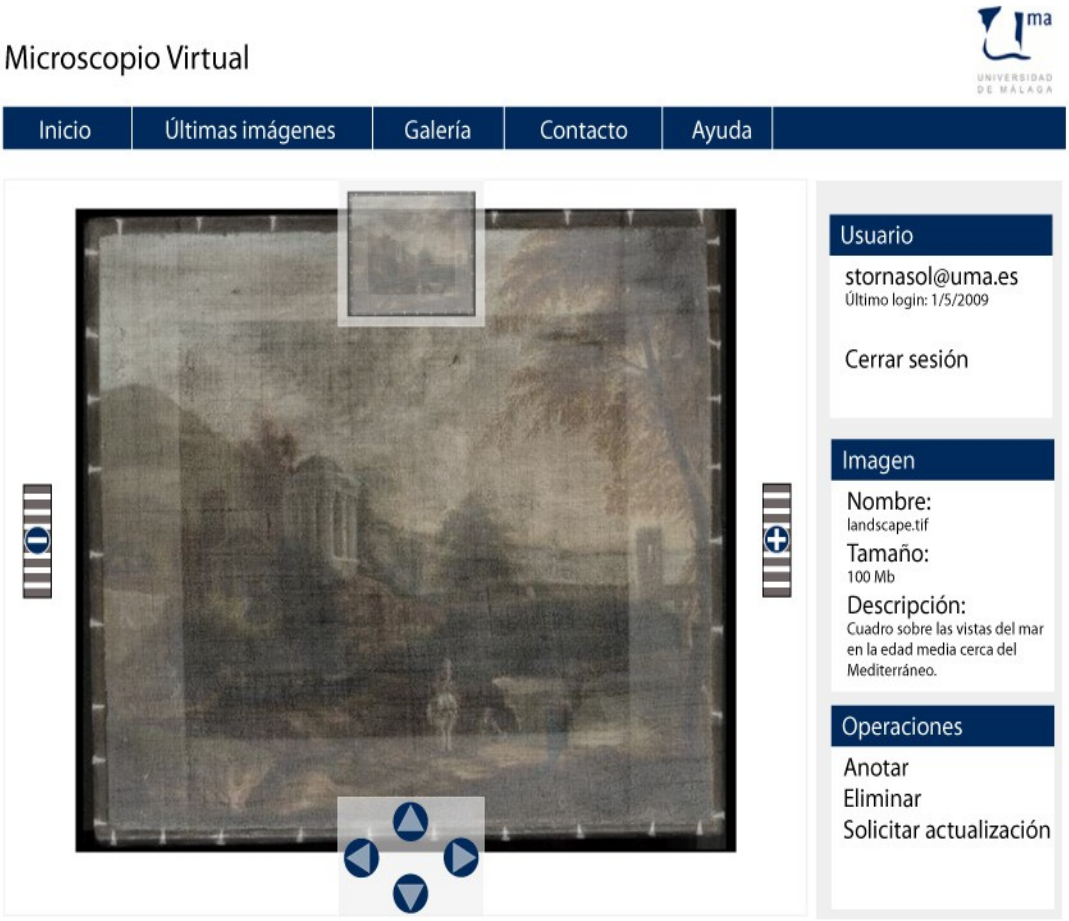

Image 2: Virtual microscope interface

6. RESULTS

We have created a web application accessible by all federated users, open source and easily shareable that can present high resolution images in an interactive way using just an Internet browser on the client side.

Preliminary tests show that the application is easy to use. It will be put into production at the start of the next academic term.

The tool improves on the user experience of a physical microscope as it can be used anywhere and can do more things, like mixing two images, or use non optical images.

The annotations have proven more complex to implement than expected because each image is divided into sectors and it is not trivial to know the magnification level and tile the user is annotating on. Yet, we are close to achieving our goal. And we like the classical opensource release early, release often, approach.

The tool is available at the RedIRIS Forge (https://forja.rediris.es/)

7. FUTURE DEVELOPMENTS

The first improvement, that is already on the pipeline, will be the annotations layers, both for teachers and students.

The initial version of the tool is focused mainly on optical microscopy for histological imaging, as it was the requirement that launched the project, but future development will also include images produced with diverse micro and macroscopic technologies.

We will start a refining cycle once the tool is in full production during the next academic term.

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