

TELEHEMATOLOGY

ICT Solution of a Shared Digital Image Repository

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Abstract: Telehematology is one of educational projects at the Faculty of Medicine of Masaryk University. The project has two various parts: the clinical part allows physicians to remotely consult their indefinite findings and the educational part brings new possibilities for contact tuition as well as for effective distant learning in a wide range of medical specialties. In this paper, the project is described mainly from the technical point of view. The design and implementation of the shared digital image repository are explained here.

1 INTRODUCTION

Hematology is the branch of medicine that is concerned with blood and its disorders. A subset of telemedicine services including digital transmission of visual information in hematology is usually referred to as telehematology (Beolchi, 2003).

Recent developments in digital photography together with the expanding use of the Internet have brought many new applications of image documentation, particularly in anatomical pathology (Leong and Leong, 2004) or in dermatopathology (Feit et al., 2005). First telehematology investigations were focused mainly on utilizing intrahospital networks and supporting clinical decision making (Mitsuhashi et al., 2000). Very specific hematologic issues are addressed in (Luethi et al., 2004), where the diagnostic accuracy in telehematology via email and in telehematology via real-time conference techniques was studied.

The goal of this paper is to describe the ICT solution of the Telehematology project at Masaryk University. The project has been initiated in cooperation with several hematooncology centres in the Czech Republic in 2006 with a long-term plan to

support medical students' access to digital microscopy images and to the documentation of diagnostics and treatment of serious diseases of the blood and the blood-forming organs.

2 ICT IN TELEHEMATOLOGY

Our Telehematology project consists of a clinical part and an educational part. It allows physicians to remotely consult their indefinite findings with the use of a shared digital image repository. The discussions as well as the images and their text descriptions are anonymous with a respect to patient information protection. In the educational part, it is available for contact tuition as well as for effective distant learning in a wide range of medical specialties.

2.1 Telehematology Workstations

Telehematology workstation is meant to be a site equipped with a laboratory microscope fitted with a digital camera which communicates through USB or Firewire interface with an ordinary personal compu-

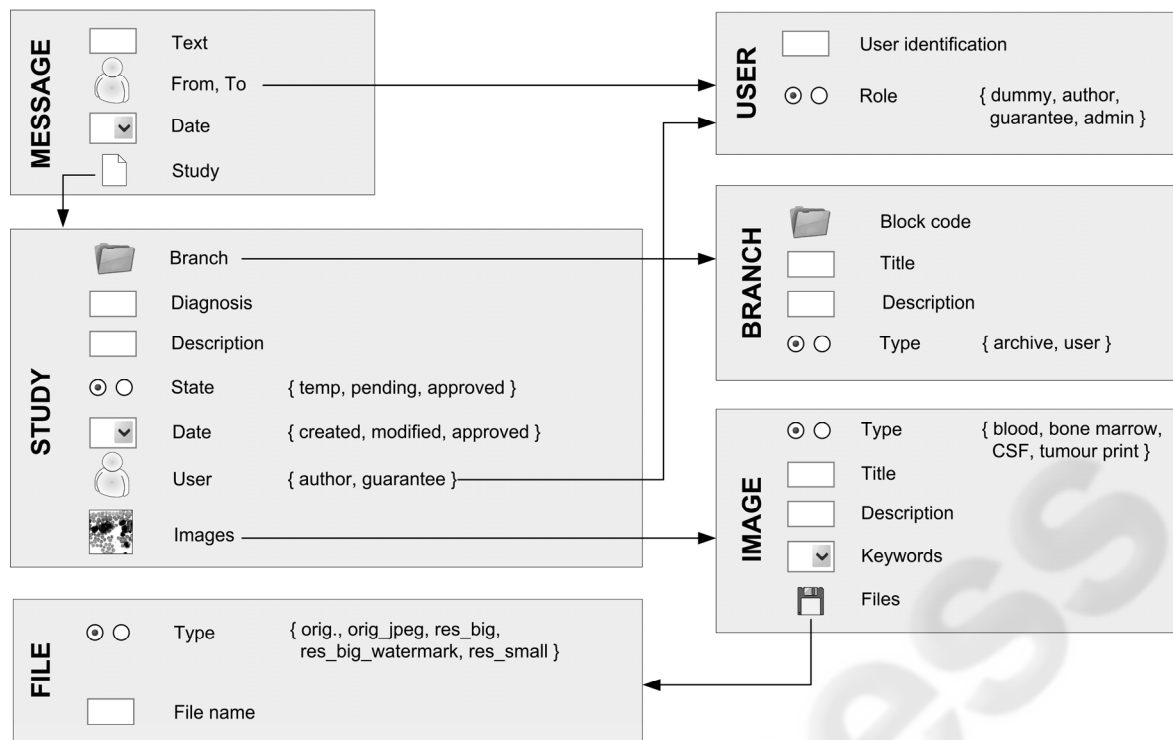


Figure 1: The simplified scheme of the shared image repository in the Telehematology project. Only the most important objects, their selected relations and properties are displayed.

ter (PC) connected to the Internet. The digital camera is usually attached to a trinocular head of the microscope with the use of a "c" mount video coupler. The communication between the camera and PC is controlled by a local software program which is usually supplied together with the camera. It is recommended to use also an additional piece of local software for advanced image editing. In order to send the captured images into the central repository and organize them in the image collection, a common internet browser is sufficient. A typical setup of a telehematology workstation involved in the Telehematology project includes a laboratory microscope Olympus BX41 (planachromat 10× and 20× objectives and a fluotar 100× objective), digital video camera Artcam 300 MI (3 Mpx, up to 46 fps, USB), optical coupler U-TV0.5X, PC control unit (Windows XP), software QuickPhotoMicro and freely distributed image editor GIMP.

2.2 Shared Image Repository

Despite the existence of various proprietary systems for digital image documentation and sharing, our original software has been developed, in order to

avoid over-reliance on technology by a single provider.

The shared digital image repository in our Telehematology project is implemented in the form of web-based application, what allows participation of any interested hematology site equipped with a telehematology workstation. The main components of the repository are shown in its simplified scheme in figure 1.

The image collection is organized in a tree-hierarchic structure. Particular tree branches represent either personal folders in the image consultation mode or diagnoses in the educational image atlas mode. In the latter case the WHO taxonomy of blood disorders is used. The tree-hierarchic structure is realized by the block code which is well-known in the field of communication techniques. It allows for arbitrarily deep branching.

The term "study" refers to a set of images captured from one case. Studies represent visual information about particular diagnoses of particular patients. Besides the images, each study contains a text description about the case. The number of images associated to a study is unrestricted. Each image is identified by its file name, text description and also by a single-choice parameter with a

following list of values: peripheral blood, bone marrow, cerebrospinal fluid, tumour print. In addition, a set of keywords selected from a predefined thesaurus may be added to each image object in order to allow advanced searching capabilities in the repository. Adding keywords from the thesaurus is implemented in the form of an interactive prompter which looks up a list of possible words compared to a searching phrase. The prompter is implemented with the use of AJAX technique to avoid extensive page reloading.

The images are stored in the repository in several versions: 1) the original file, 2) a copy with the original resolution converted to the JPEG format, 3) a converted copy resampled to VGA resolution (640×480), 4) a watermarked copy in VGA resolution and 5) a thumbnail resampled to 75 px along its longer side. All the image operations are done automatically without any user's intervention. Users may send images in arbitrary format. Format conversion, image resampling and watermarking are performed with the use of the freely distributed program ImageMagick. The computer on which the application is hosted is equipped with the Linux operation system, web server Apache and database server MySQL. Own programs of the shared image repository are written with the use of the scripting language PHP.

2.3 User Roles in Telehematology

The list of user roles in the image repository together with a description of user privileges follows. 1) Author: user may create new studies and edit existing own studies in the TEMP and PENDING state. The user may send messages to other authors and guarantees and associate the messages to particular studies. 2) Guarantee: user checks studies in the PENDING state, i.e. the studies which are completed by their authors. The user may change the state of studies from the PENDING to the APPROVED state. The user may send messages in the same manner as an author. 3) Dummy: the end-user of the shared image repository, who may only view the studies in the APPROVED state. User's view is restricted only to the resampled and converted images. Anonymous users may view only watermarked images. 4) Administrator: user with all privileges, who performs supervision over the repository. The user can extend the thesaurus of keywords or modify the hierarchic-tree structure of the image collection according to new requests from the guarantees.

All roles except the administrator role can be assigned not only in the global manner for the whole repository, but users may be granted also within a restricted subset of the tree-hierarchic structure.

3 PRACTICAL ASPECTS

During the initial phase of the Telehematology project there was a variety of difficulties which had to be cleared. The most important component of the project was always meant to be a stable and user-friendly shared image repository. Thus, the worst difficulties had been expected in this part of the project. However, the worst problems finally came out from the quality of captured images. Most of CCD as well as CMOS digital cameras which were tested required additional image editing in order to compensate for errors in white balancing. Images with an incorrect mixture of primary colors (red, green, blue) are not suitable for education purposes. In addition, such images with a color cast did not either motivate hematologists to extend the image collection nor to utilize the software resources of the project for image consultation. Having employed advanced image operations with the use of the software GIMP solved the problem.

During the first year of operation the authors have stored 336 images organized into 52 studies from which 31 have been still in the TEMP state and only 13 studies have been in the PENDING state. Only 7 studies have achieved the APPROVED state, what has showed us that the communication tools provided for authors and guarantees need to be improved, in order to speed up the process of revising studies into their final versions.

The importance of our Telehematology project lies in enabling students to access a well-organized and described collection of digital microscopy images for their undergraduate as well as postgraduate education in a wide range of medical specialties such as hematology, biology, histology, anatomical pathology, oncology etc. The web-oriented character of the project allows utilization of the gathered image material for the contact tuition as well as for self-study purposes.

Students at the Faculty of Medicine of Masaryk University usually find their multimedia and e-learning materials with the use of faculty's educational portal <http://portal.med.muni.cz>, which is described in (Dusek et al., 2006) in detail. The reference to the Telehematology project is included there among plenty of others.

4 CONCLUSIONS

In this paper, the Telehematology project at Masaryk University was presented, mainly from its ICT point of view. Key problems lying in the quality of captured images were mentioned.

The most original part of the developed image repository from the user's point of view is the thesaurus of keywords implemented in the form of the interactive prompter. Its usage avoids scrolling obscure long lists or time-consuming searching in tomes to get a right term.

The major part of the ICT solution for the shared image repository in the Telehematology project is used also in other web-based learning applications at Masaryk University, such as Image Atlas of Digital Mamography, Image Atlas of Dental Surgery, 3-D Models in Nerosurgery and many more, which are connected to medical image documentation.

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