

The Italian Network of Telepathology

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BACKGROUND: At the end of 1999, the Italian Ministry of University and Research selected and funded the project entitled "Italian Network of Telemedicine for Research Education and Quality Control in Anatomic Pathology" as a project of relevant national interest.

The main network activities are: collaborative research projects development, based on telematic tools; remote expert consultation; creation of multimedia case archives for education and continuing education; collaborative authoring of multimedia educational material; quantitative pathology studies carried out through telematics; study and application of telematic methods for quality control in anatomic pathology.

Two kinds of results are expected: results from collaborative telepathology-based research subprojects and methodological results: tools and guidelines coming from this experience, which will allow to further extend the network to other participants.

The project is headed by the Institute of Pathology at the University of Udine, and currently involves other four Italian universities (Ancona, Bari, Ferrara, Sassari). Such network will allow a greater collaboration among participants, and will be also open to other medical disciplines, becoming in this way a model which can be adopted in a wider context. Part of the project regards teleconsultation activities, here described.

MATERIALS AND METHODS: The Internet being a widely diffused and not expensive communication tool, has been chosen as the mean for carrying out telepathology activities inside the Network. By using the Internet, remote expert consultation can be carried out in two main ways: through multimedia email and through Web-based systems. Aim of the project is to test and possibly to integrate both methods, giving also privacy and security to communications.

Technically, cases have been exchanged first with email, and then with a Web-based telepathology tool (implemented with MySQL, Apache, OpenSSL and PHP on a Linux server). Each network partner acquires images with a digital videocamera (usually Olympus or Nikon), then uploads cases into the server. Insertion of cases is possible only to registered users, while consultation is currently open to public. Exchanged cases are selected among those strictly needing a second opinion consultation, i.e., really difficult or rare cases.

RESULTS: Being the network just started, only preliminary results can be provided. Diagnostic accuracy is good, although the difficulty of cases made it difficult to agree even on glass slides. The median number of images -6- is slightly higher than previously reported experiences. Instead, the median storage size of a case -2.5 MB- is greatly higher, due to the new digital photocamera used in the project, which allow for greater resolutions and thus for higher file sizes.

CONCLUSION: Relatively inexpensive tools may allow pathologist to increase collaboration, not only in the now traditional telepathology fields such as telediagnosis and remote consultation, but also for educational and quality control aims. Furthermore, every form of collaboration has a positive secondary effect the continuing education of the pathologist.

KEY WORDS: Telemedicine; Telepathology; Telediagnosis

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INTRODUCTION

The Italian Ministry of University and Research selected -and consequently funded- the project entitled "Italian Network of Telemedicine for Research Education and Quality Control in Anatomic Pathology" as a project of relevant national interest. The

project is headed by the Institute of Pathology at the University of Udine, and currently involves other four Italian universities (Ancona, Bari, Ferrara, Sassari). Such network will allow a greater collaboration among participants, and will be also open to other medical disciplines, becoming in this way a model which can be adopted in a wider context.

The network is based on easily available standard protocols and communication tools, with particular attention to the Internet. Both main sets of its protocols, i.e., email and WWW, are exploited in order to give the pathologist an easy access to networked resources.

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The main network activities are:

- collaborative research projects development, based on telematic tools;
- creation of multimedia case archives for education and continuing education;
- collaborative authoring of multimedia educational material;
- quantitative pathology studies carried out through telematics;
- study and application of telematic methods for quality control in anatomic pathology.

Being the network just started, only preliminary results can be provided. In particular, two kinds of results are expected inside the project. The former derives directly from the cooperative research subprojects that are ongoing inside the network (i.e., diagnostic concordance assessment, morphometry, etc). The latter is the set of methods, tools and guidelines coming from this experience, which will allow to further extend the network to other participants.

The rest of the paper will describe the architecture underlying the most part of the project, security considerations, and some ongoing application.

ARCHITECTURE

The main activities of a telepathology network are centered around multimedia case transmission. In our intentions, many applications are to be carried out starting from this, and including telediagnosis, distant education, quality control. So, a basic case structure has been defined as composed by case data, case author (the pathologist), images, enhanced with a data table for dialogues about cases and eventual educational extensions (i.e. more specific clinical history, questions and answers, etc). Such database is to be deployed inside a three-tier infrastructure, where the most sensible data are kept in a database while interfaces and even images are maintained in the middle layer.

Data and images regarding cases are sent and received by clients where mainly a Web browser is present. The browser contacts the middle layer, where security and privilege checks are made, while such layer extracts the requested patient data from the database server, situated in a protected area.

Images are acquired by means of digital cameras, which are currently giving up to 1600x1200 pixels. An alternative with higher resolution but long acquisition time is the photoscanner, which has a linear CCD moving on the image field and gives up to 3400x2700 pixels (1). High resolutions have been used also in collaborative transnational studies carried out by the network partners (2).

SECURITY CONSIDERATIONS

When carrying out a consultation, the two parties need to (3):

- securely and privately transmit the case and the answer,
- acknowledge the receipt of data,
- have the certainty of the other's identity,
- and have the certainty of the other's qualification, if not personally known.

Either email and web have been used for telepathology consultation, but only recently their security and privacy features have been experimented.

Email allows privacy-enhanced communications through S/MIME, using public key cryptography and digital signatures. An optional form of acknowledgement of receipt is also available. User authentication, needed for digital signatures, relies on certification authorities (CA).

Web security features include the HTTPS protocol (for secure connections between client and server), form signing, and various forms of locally developed user authentication. In general, by means of forms, and server-side computing (CGI, servlets, etc) it is possible to implement different schemes of interaction.

In evaluating the security needs of our architecture, some point has been considered:

- * there is the need of having private communications for almost all data on any connection between layers;
- * there is the need of identifying the client user, except when he or she access the data only with educational aims (so, only restricted data);
- * there is the need of signing any communication regarding cases, when it is related to diagnosis.

Such considerations lead to the addition of security features to the previous scheme, based on HTTPS, SSL, SSH and a certification authority (4)

IMPLEMENTATION

All the system underlying the network is being implemented using as many Open Source software as possible. In fact, at the present time the basic Operating system chosen for the database server is Linux, while the middle layer is hosted on Sun/Solaris, and on both different software modules have been adopted, as follows:

- * Database: the choice is between MySQL, PostGreSQL and Interbase, although currently MySQL is used.
- * Web server: Apache v1.3.14
- * Dynamic interface: PHP v4.04pl1
- * SSL communications: OpenSSL, with the mod_ssl module for Apache
- * SSH communication: OpenSSH
- * Certification Authority: after considering the acquisition of com-

mercial certificates, we decided not to proceed in that direction, because the level of user authentication usually given by a commercial CA is low, as based only on email verifications. Thus, we started implementing a CA based on the OpenCA effort, which is in turn based on OpenSSL, Perl and Apache.

Part of the work is still ongoing, thus not all the modules are yet available.

In particular, the choice for MySQL (faster than others) is being reconsidered, because it does not allow a clear transaction management, where more than one database modification is made, while PostgreSQL allows also this.

APPLICATIONS AND FIRST RESULTS

The main experimental application carried out regards telediagnosis, where each network partner sends really difficult cases to other partners, obtaining thus a set of second opinion diagnoses. Although code are still not broken, the following table shows some detail about the cases (average values, minimum and maximum).

Table 1. Case summary

Case	No. of images	MBytes
Skin lesion	5	2.1
Breast nodule	6	0.9
Prostatic lesion	4	0.3
Cerebral lesion	7	2.2
Cerebral lesion	5	2.5
Cerebral lesion	10	3.1
Intrasternal mass	5	2.3
Nodule in leg	5	2.0
Cerebral neoplasia	6	3.5
Cutaneous lesion	8	4.7
Hernia	7	4.2
Spleen	7	4.3
Soft tissue - Thorax	7	1.8
Cerebral lesion	6	2.9
Colic mucosa neoplasia	6	1.0
Cerebral neoplasia	6	1.8
Soft tissue neoplasia	5	2.0
Colic neoplasia	6	2.1
Skin lesion	8	2.7
Lip lesion	5	2.0
Liver	5	1.8
21 cases	6.1 (5-10)	2.4 (0.3-4.7)

Other ongoing applications are devoted to education, following two directions. One is given by the constitution of an educational case archive, currently having cases provided by residents; the other by creating an archive of presentations about Anatomic Pathology topics, to be used by teachers during lectures and also students for self-learning (5). The next figure shows a typical educational case, reacher than those used for consultation.



Figure 1. Typical educational case

Other applications, still not fully deployed, regard quantitative telepathology and quality control.

DISCUSSION

Inexpensive tools may allow pathologist to increase collaboration, not only in the now traditional telepathology fields such as telediagnosis and remote consultation, but also for educational and quality control aims. Furthermore, every form of collaboration has a secondary effect the continuing education of the pathologist.

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