PROJECT TIPRIX (integration of teleradiology using Low-cost digitalization of X-ray films): a Brazilian solution

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Authors: A. Monteiro\textsuperscript{1}, A. A. S. M. Santos\textsuperscript{2}, A. BHAYA\textsuperscript{1}, P. R. V. Bahia\textsuperscript{1}, M. L. O. Santos\textsuperscript{2}, A. L. E. D. NEVES\textsuperscript{1}, J. Grande\textsuperscript{1}, L. V. Ferreira\textsuperscript{1};\textsuperscript{1}\textsuperscript{1}\textsuperscript{1}Rio de Janeiro, RJ/BR, \textsuperscript{2}\textsuperscript{2}Niterói - Rio de Janeiro, RJ/BR

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Learning objectives

- Demonstrate low-cost solution for scanning X-ray films.
- Show the feasibility of a multi-institutional project to collaborate in public health, helping to improve diagnosis and treatment of patients with lung diseases, especially tuberculosis, in State of Rio de Janeiro, Brazil.

Background

- Lung diseases are prevalent in public health, with a recent increase in the incidence of tuberculosis in Brazil.
- The main project goal is to provide a low cost solution to the problem of lack of radiologists in remote areas in Brazil, which has continental dimensions, by providing a method to digitalize conventional X-ray films and transmitting them to teleradiology centers via Internet, where qualified radiologists can provide second opinions, which are then returned to the remote areas by Internet.
- In Brazil, the Federal Council of Medicine (CFM) regulates and in order to and ensure good medical practice throughout the country.
- Article 5 of this Resolution in its article 5 states: In case of general non-contrast radiology, excluding mammography, the physician responsible for the patient may request the appropriate diagnostic support from a remote specialist (radiologist).

Main objectives of the Project TIPIRX:

- Identification of a sustainable low-cost solution to produce digital images from conventional X-ray films.
- Development of image stitching software for digital image acquisition using commercial scanners.
- Research on feasible level of visually lossless compression of radiological images.
- Training of radiologists (staffs, medical residents and fellows in Radiology) from three university hospitals in the State of Rio de Janeiro (UERJ, UFRJ and UFF), for digital radiology.
- Acquisition and installation of equipment for high-quality radiological images (Computed Radiology-CR).
- Training for teleconsulting in digital radiology at University Hospitals.
• Training of medical staff and technicians for the digitalization of X-rays films with commercial scanner and using software developed by the project team.

• Second-opinion primarily for chest X-rays (social impact: improving the diagnosis of pulmonary tuberculosis): 8 units in teleradiology in the public health sector in State of Rio de Janeiro.

• This project was funded by the Brazilian Innovation Agency for Research and Project Financing (FINEP).

Imaging findings OR Procedure details

Procedure Details

• Creation of a multidisciplinary team, involving radiologists, engineers, information technology professionals and others.

Participating institutions:

• UERJ: State University of Rio de Janeiro (Project Coordination): through the Telehealth Center/Rio de Janeiro and Radiology Service HUPE.

• High Performance Computing Center (NACAD) at COPPE/Federal University of Rio de Janeiro.

• Radiology Service HUAP/ UFF (Federal Fluminense University)

• Radiology Service HUCFF/UFRJ (Federal University of Rio de Janeiro)

• **Problem situation**: to be resolved by the team of **engineers** from COPPE / UFRJ: low-cost scanners X adequate digitalization X image compression

• **Problem situation**: to be resolved by the team of **radiologists**: adequate digitalization x approval staff radiologists X digital radiology and teleconsulting (paradigm shifts).

Low-cost digitalization of X-ray films:

• The simplest choice of scanner to digitalize X-ray films with acceptable quality would be to use a medical image digitizer that is designed to scan large format objects, such as X-ray films.

• The price of such digitizers is, however, about eight times that of an A4 size scanner that is able to produce images of comparable quality, except that they are limited to A4 size.

• We evaluated seven commercial scanners.
• Since most X-ray films are larger than the A4 size image capturing area of the scanner, this required the development of an image processing algorithm that could stitch two or four partial images of the whole X-ray film, depending on its size, into a seamless full image of the film.
• We developed a software to digitize chest x-rays at low cost (ScanRX).

**FIG.1.**
• Chest radiographs come in five different sizes, of which only one fits the A4 scanner window used by scanRX.
• The solution adopted is to digitize the film in 1, 2 or 4 parts, depending on the film size, and then to stitch together the partial images to obtain a digital image of the whole film.
• This technique is known as image stitching [1-2] and a specific algorithm, reported on elsewhere [3], was developed to this end.
• In order to stitch the images correctly, it is necessary that each part of the film to be digitized be positioned correctly in the scanner window.
• The user informs the software, through a dialog box, about the size and orientation (portrait or landscape) of the film since this information is crucial for the success of the stitching algorithm. **FIG.2.**
• With this information in hand, the software scanRX guides the user through a step-by-step process of digitization of the film, in order to obtain a correctly stitched digital image of the whole film, saved in a DICOM dataset (FIG 3-6).
• The image is compressed with lossy JPEG with quality 85, since this corresponds to a JPEG compression at a ratio of 10:1 and is visually lossless at close inspection [4].
• The largest images given by scanRX are around 700KB and can be easily transmitted using low bandwidth Internet connections (FIG.7).
• The proposed image stitching algorithm produces high resolution seamless images with good contrast and quality that permits their use in this teleradiology project.
• ScanRX was developed exclusively with free tools and open source libraries and has a user-friendly interface.
• The scanRX software has been tested exhaustively and hundreds of X-ray films of all sizes have been digitized, examined and approved by radiologists of three major university hospitals.
• This software is now operational in eight remote locations in the State of Rio de Janeiro/ Brazil, and currently generates requests for second opinions in cases of pulmonary diseases, specialty tuberculosis.

• After the development of software and made all tests, the next step was to train technicians from public health clinics to learn to manipulate the system and send the images over the Internet for teleconsultants (teachers of Radiology University Hospitals that are part of this project).
• Another important step was to disseminate among the physicians this new option for the diagnosis, using teleradiology, which until then was totally unknown in public health in Brazil.
• To facilitate and expedite this process, was created and provided a system (TeleRX), by the Telehealth Center/Rio de Janeiro, for sending teleconsultants (clinical data and images), to which the referring physicians and radiologists have access after registration and use of personal password: www.telessaude.uerj.br/riotelerx (FIG.8).

• On the first page of this system, the user is identified. Then, the requesting physician reports all the data concerning the patient will be evaluated by teleconsultants and sends the scanned images, as well as questions regarding the radiological aspects of the case (FIG.9).

• The examination is then sent to a radiologist of three university hospitals, following a previously established order.

• The teleconsultants has a maximum of 48 hours to issue its opinion and return it to the requesting physician.

• Each radiologist has access to its list of cases, are marked where the reports already issued, the new tests that were sent and are awaiting the opinion, as well as responses from referring physicians, who send a feedback whenever possible (FIG.10).

• Each new case submitted, the system sends an email to inform the teleconsultant.

• If for some problem, teleconsultants period exceeding 48 hours, the system automatically generates another email informing him about the delay, with copies to the Project Coordination, which will investigate the reason for the delay and even redirecting the case to another teleconsultant.

• We implemented the integration between radiologists in university hospitals with doctors working in public health in State of Rio de Janeiro, for providing images teleconsulting.

Images for this section:
Fig. 1: Software scanRX.
Fig. 2: A dialog box, about the size and orientation (portrait or landscape) of the film.

Fig. 3: Step 1 process of digitization of the film.
**Fig. 4:** Step 2 in process of digitization of the film.

**Fig. 5:** Step 3 process of digitization of the film.
**Fig. 6:** Step 4 in process of digitization of the film.

**Fig. 7:** Final part: the system informs the technician that the image was saved in DICOM format.
Fig. 8: TeleRX: System for sending teleconsultants.
**Fig. 9:** Identification of who is using the system (requesting physician, teleconsultants, coach or coordinator) and patient data.
**Fig. 10:** Control of teleconsultation with the options: open, analyzed, conference schedule, requested supplementary information. Teleconsulting also concludes that the term is completed or expired.
Conclusion

The TIPIRX is a low cost project that has helped to improve the public health care in Rio de Janeiro, allowing the use of teleradiology in pulmonary diseases.

Personal Information

Alexandra Maria Vieira Monteiro. MD, PhD.

Corresponding Author. Adjunct Professor of Radiology, HUPE/ UERJ Medical School. Coordinator **PROJECT TIPIRX** and Coordinator of Telehealth Center, State University of Rio de Janeiro.

Email: monteiroamv@gmail.com

e-curriculum: http://lattes.cnpq.br/4182784247902426

Alair Augusto Sarmet M. D dos Santos. MD, PhD.

Associate Professor, Department of Radiology and Head of the Radiology and Diagnostic Imaging Service of University Hospital Antônio Pedro (HUAP) /UFF (Federal Fluminense University) - Niterói, RJ, Brazil.

Email: alairsarmet@globo.com

e-curriculum: http://lattes.cnpq.br/1215394507629695

Amit Bhaya. Ph.D., U. C. Berkeley

Professor of Electrical Engineering. NACAD/COPPE/UFRJ.

E-mail: amit@nacad.ufrj.br

http://www.nacad.ufrj.br/~amit

Paulo Roberto Valle Bahia. MD, PhD.
Associate Professor, Department of Radiology and Head of the Radiology and Diagnostic Imaging Service of HUCFF/UFRJ. Rio de Janeiro. Brazil.

E-mail: vallebahia@gmail.com

Maria Lucia Oliveira Santos. MD, PhD.

Associate Professor, Department of Radiology. University Hospital Antônio Pedro (HUAP) /UFF (Federal Fluminense University) - Niterói, RJ, Brazil.

Email: mlucia.santos@gmail.com

J. Grande: Post-graduate student. E-mail: jaimegvela@yahoo.com.br

L. V. Ferreira: Post-doctoral fellow. E-mail: lvferreira@gmail.com

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