Obtaining digital files from radiographic films

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ABSTRACT. Digitizing images with low cost off-the-shelf technology arises as an alternative to storage films in developing countries. The objective of this work is to determine a low-cost method to digitizeRx films for educative and remote-consult purposes. To this aim, different ways of digitizing were compared against conventional methods to determine the feasibility to have a simple-low cost method that is quality independent from facilities and operator. Different images from digital photo cameras and scanners (with or without transparency adapter at different resolutions and color depth) were analyzed. We present preliminary results for digitizing Rx films with a fast and simple inexpensive system that capture quality images, and optimal sizes for storage in basic PCs in hospitals, with the possibility of asking for a second opinion via e-mail or through a web-based service. It must be noted that in many cases the only way of communication is via dial-up telephone line.

1. Introduction
Image digitizing and storage have become part of many radiological practices. State-of-the-art technologies advance toward goals of capturing and displaying images of high quality for diagnostic interpretation. These are not simple, and call for operators with knowledge on digital images. [1], [2].

The students —the main recipients at this work stage— use the radiograph films as study material, thus gaining knowledge more efficiently and encouragingly than with imaging and supplementary material found in Internet. For these purposes, and for remote consulting, the requirements are smaller than those for diagnosis. Therefore, it is possible to procure and store them with lower costs. [1], [3].

There are different methods to obtain a digital image. We can mention film digitizers (very expensive and falling into disuse with the advent of digital radiology) and fast-spreading electronic means, like digital photo-camera and flat table scanners.

At present, image digitizing via digital photo-camera is generally faster than with flat table scanners. A common characteristic for both methods is that the user can set many parameters to digitize. High-end scanners with transparency adapters are the best means to generate radiological images to display on PC monitors, either in healthcare institutions with PACS or at remote sites with a dial-up connection. Image banks that include the most common pathologies in a region allows the students to learn about the maladies using real images and supplementary material via. [1], [4], [5].

The image file format can be Tiff, PCX, BMP or GIF and, in all cases, the lossless JPG format is used to compress data. The standard JPG2000 is applied when lossless gray depth is needed. [2], [4].

The objective of this work is to determine a low-cost method to digitize Rx films for educative and at-distance consulting purposes. In order to achieve it, parameters like quality, files size, time of
acquisition and the physician’s expert eye opinion were evaluated. Digitizing was performed with
c conventional low-cost methods.

2. Materials and methods
In this stage 20 Rx films of 24x30cm and 18x24cm from the Hospital de Maternidad Nuestra Señora
de las Mercedes were used. Digitizing was performed with a scanner EPSON PERFECTION 2480
PHOTO with optical resolution of 2400x2400dpi and 16 bits of gray depth.

The images were digitized at resolutions of 300, 600, 1200, 2400 dpi, 8 and 16 bits of gray depth
and at 24 bits color depth. A transparency adapter was implemented using off-the-shelf components
and three 15 W daylight fluorescent tubes that radiate a uniform luminance of about 5000 Lux.
Digitizing was performed with and without transparency adapter. In all cases, the acquisition time was
recorded with a manual chronometer.

The auxiliary digitizing devices have different levels of luminance; therefore, it was necessary to
dermine the range for the different light sources. To measure this, a luximeter MASTECH MS8209
was employed, and different points -over the view-boxes and the scanner platen- were evaluated.[7].

Also, a 4 MPx digital photo camera OLIMPUS 545 was used. Photo shots of the Rx films were
taken; then, they were placed on a commercial box-viewer, at different distances (40, 80 and 120 cm)
in a low-lighting environment, with and without flash. In all cases the camera was mounted to a tripod
and the shutter was remote cable operated to avoid movement artifacts. The images were processed
and saved for visualization on a PC SEMPRON 2.6 with 1Gb RAM, HD ATA 133, video NVIDIA
TNT2 M64 AGP at 1024x768 in a 15” CRT monitor. Data were saved in Tiff and JPG files, to lose
less gray depth it was also used JPG2000 or JP2 format.[5].

The image analysis was performed with ADOBE PHOTOSHOP CS3 10.0 beta version plus a
JPG2000 plug-in; the histogram was analyzed in MATLAB 7.0. An expert, who made a visual
comparison between the original films and the digitized images, judged the image fidelity. In this case,
the image visualization was on a notebook Dell Inspiron I6400, Intel Core Duo T2250 1,73 GHz, 2 Gb
RAM, video ATI Mobility Radeon X1400 at a resolution of 1440x900 pixels.

3. Results
A. Digitizing with flat-table scanner

Figure 1 shows the acquisition time, in seconds, as a function of resolution and gray depth.

![Figure1. Acquisition time (sec) vs Resolution for 8 and 16 bits of gray depth](image)

It is clearly observed that the acquisition time for a resolution of 2400dpi and 16 bits of gray depth
is about 1200 sec (20 min). With the same resolution, but with a gray depth of 8 bits, time is about 5 or
6 minutes. For the other cases, 300-600-1200dpi and gray depths of 8 and 16 bits, the time was less
than 3 minutes
When the file size is analyzed, it is observed that there is a pronounced difference, depending on the storage format. Figure 2 shows the Tiff format size, in megabits, for 300-600-1200-2400 dpi, gray depth of 8-16 bits and 24 bits color.

![Tiff file size](image)

**Figure 2.** File size (Mb) vs Resolution at gray depth of 8-16 bits and 24 bits color for Tiff format

Figure 3 shows the JPG format size for 300-600-1200-2400 dpi, gray depth of 8-16 bits with a compression rate of 15% (greater rate imply more loss).

![JPG file size](image)

**Figure 3.** File size (Mb) vs Resolution at gray depth of 8-16 bits for JPG format

Tiff file sizes are between 6 to 730 Mb, the last value is for 2400dpi of resolution and 16 bits of gray depth. JPG file sizes are between 300Kb to 14Mb, with a rate compression of 16. Figure 3 shows that for 8 and 16 bits these values are almost the same. This is so because the JPG algorithm transforms the 16 bits gray depth into 8 bits. Because of this, JPG2000 (JP2) format is used for 16 bits of gray depth, being the sizes obtained about hundreds Kb in lossless format.
An 8 Mb tiff file becomes into a 3 Mb file when is saved in JP2 lossless format. If the same file is saved with a 75% quality rate compression (1:3), the size is about 170 Kb. At first sight, it can be seen that histograms do not show significant differences in any case; but this conclusion needs to be validated statistically.

For histogram analysis, it was assigned a 100% to the absolute values of gray depth for 240 dpi, for 1200 dpi this values are about 20%, 5% for 600 dpi and 1% for 300 dpi, for depth of 8 and 16 bits these differences were no significant. In all cases, the percentage values of gray depth distribution were the same.

B. Digitizing with transparency adapter

The devices to optimize image digitizing have different levels of luminance that are necessary to be determined. With this purpose, different measurements were made under the same conditions placing the instrument at a distance of 30 cm and making a sweep of the whole illuminated surface. The obtained values were about 529-670 lux for the box-viewer, 350-490 lux for the transparency adapter and 180-230 for the scanner.

Figure 4 shows two histograms of the same image when it is digitized with and without transparency adapter.

![Figure 4. Histograms when digitizing is performed without transparency adapter (gray line) and with transparency adapter (black line)](image)

When digitizing is performed without transparency adapter, the histogram shows a high concentration in the black and white zones. When the same process is made with transparency adapter, it shows a better spread from the white zone to near the black zone. At first sight, it can be noted a better distribution with transparency adapter, because of a better discrimination of grays.

The first images acquired with our transparency adapter showed a striping, similar as a flickering effect, when digitizing was performed at a lower resolution than 1200 dpi. Figure 5 shows one of the images with this effect; this was shown with either 8 or 16 bits of gray depth. This effect was diminished for 1200 dpi, and was non observable for 2400 dpi.

This problem was tried to be solved by powering the tubes in counter-phase, obtaining images as show in Figure 5B. The striping effect was significantly reduced, but when successive zooms were performed, the effect became perceptible. At present, this problem is under way of being solved.
C. Digitizing with digital photo camera

Although there are papers that emphasize the affinity of digital photo camera method to digitize Rx films [3], tests performed in our laboratory were not completely satisfactory. Photos were taken in a dark environment at 40, 80 and 120 cm of distance with different camera configuration. On the other hand, image quality was greatly dependent on environment and operators.

4. Discussion and conclusions

Commercial digitizers capture images at 8 and 12 bits of gray levels, despite the fact that the human eye can discriminate up to 256 levels [6]. But these instruments practically fall out of reach for a large number of institutions in our region, and are falling into disuse with the advent of digital radiology. Because of this, other alternatives were looked for in order to generate image banks, of real cases, for education and remote consultation with good quality images suitable for electronic transmission.

The digitizing for 1200 and 2400 dpi were discarded because of the acquisition time and the fact that there is no major information in the visualization. Tiff file sizes are very significant, making its management little effective: the hard disks get full fast, and are little suitable for electronic transmission, mainly when the only available service is dial up.

JPG files are more suitable because of their smaller size than tiff files and greater compression capability. The new standard JPG2000 must be applied when the requirement is to maintain 16 bits of gray depth. It also has new and better capabilities for compression giving the option of lossless format.

The evaluation of this method by experts is at a preliminary stage. Nevertheless, the current data are satisfactory, and a first preliminary conclusion is that Rx films digitized at 300-600 dpi with 16 bits of gray depth, even 8, with transparency adapter and saved in JP2 format are suitable for educational purposes. To validate this method for diagnosis or remote consultation, the ROC analysis will be performed in a continuing work.

5. References

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