An utility & ImageJ-macro for ribcage suppression on chest-radiography images by statistical elimination of rough Radon's laplacians in CPU.

1. The ratios

This package:

1a) consists of ImageJ-macro & Win64-binaries";

1b) targets developer's cognitive interest to compare algebraic filters of ~mid 20th century vs. nowadays "deep learning" and/or a bit older "convolution networks";

1c) assumes BSD-license (free usage, distribution without warranties).

The binaries aren't an open source. The work-flow is <technically> single click (without explicit HW-specific parameters).

1.1. Objective constraints

1.1a) Adult person's radiography by Flat Panel Detector ~43x43cm of 2999x2999..3999x3999pix (pixel_pitch 0.13-0.16mm).
It excludes the most of CMOS FPDs, high-end TFT FPDs of ~40x40cm with ~>4000x4000pix.

1.1b) $MTF(1.5_{1/mm})>0.5$; $MTF(F_{Nyquist})<0.05$; $DQE(0_{1/mm})>0.66$ (when measured in accordance with IEC62220-1).
It excludes the most typical GadOx TFT FPDs of 3072x3072pix (from manufacturing lines equipped ~< year 2019).
Note1: FPDs' manufacturers frequently report insane $MTF(F_{Nyquist})$~>0.1, which indicates simultaneously huge aliases and illiteracy of technicians (unless a firmware incapsulates intelligence beyond human's one).
Note2: FPDs' manufacturers frequently report fake DQE (calculating NPS by dark frames of shorter integration-time and/or lover reference voltage than bright ones).

1.2. Motivations of the constraints

The algorithms behind this utility refer ~earlier 1980th, when an anti-aircraft missile targeted by couple of heterodynes and a cruise missile without a CPU recognized rail-roads on video. Here are just hard-coded algebraic filters. The whole projects' code amount is <5000 lines (linking against C-language RTL and few Windows APIs). By subjective estimation this is ~3000 times shorter than code's amount (if count by the same metric) of a project using nowadays "MTANN" or ~500 times shorter than older "convolution networks".

Drawbacks of the simplicity are:

- the reason of "1.1a)":

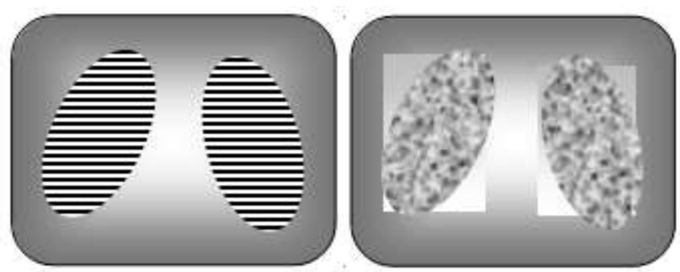
Statistical determination of posteriors' arcs and anteriors' convexes refers expecting ribs' width as cardinal const 99pix. That is easy but doesn't suit for small pixel_pitch of high-end FPDs.

- the reason of "1.1b)":

Der Shwerpunkt for Radon's laplacians is to determine lungs' areas globally (it needs good dynamic range of signal to distinguish lungs' cupolas by ~thresholds). Standard & robust alternate approach is application of "active contours" for "Pavlidis' contours". Other alternate approach is User Interface for areas' selection (which will not work in single-click however). Both alternates have less cognitive interest and need more debug than conceptually-plain Radon's filters (both are beyond of time-budget of this freeware).

1.3. The work-flow

stage 1) As preliminary training, a radiographer comprehends (by relevant data-series) how the process' options below eliminate specific encumbering images' entities.



stage 2) If an image (that fits "1.1a)") contains specific encumbering entities then radiographer might optimize conspicuousness of important entities (empirically combining relevant process' options). The target is not to remove RibCage completely but reduce one (until risk to kill important entities). Shadow rectangles around the lungs (not too prominent but easily visible on optimized image) explicitly indicate changed areas.

stage 3) The radiographer might consider optimized image with smaller zoom and lesser fatigue, then refer suspicious areas (if are) in original image.

2. Brief description

2.1. Process' options

Each of three options below eliminates certain kind of Radon's laplacians:

2.1a) #1 *Descend peripheral_to_center* (reduces clavicle, prominent ribs),
2.1b) #2 *Arc-shapes* (reduces posteriors),
2.1c) #4 *Concave-shapes* (reduces clavicle, anteriors).

Here #1, #2, #4 are bit-wise options' codes (look plain when summ into single process-code).

Drawback of the simplicity: despite intuitive expectation, option "2.1c)" rarely distinguishes weak anteriors but rather subtracts clavicle (having opposite curvature against statistically-dominating posteriors).

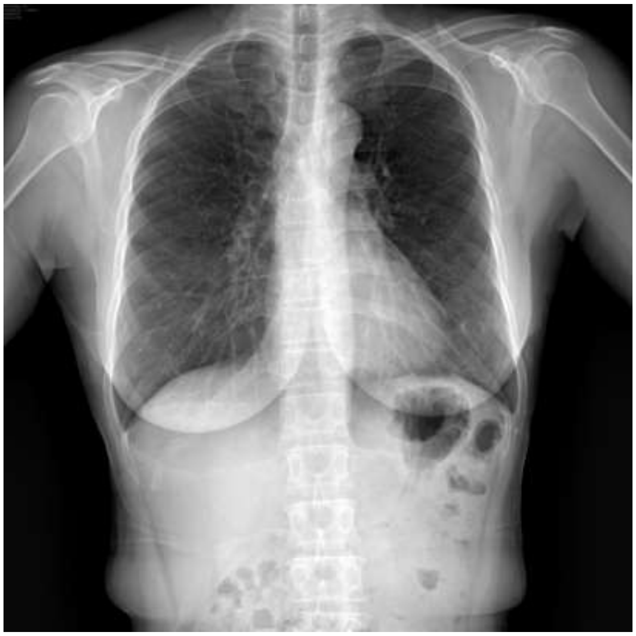
2.2. Working "Example0.DCM" (2-years old middle-end TFT 43x43cm, 3268x3268, CsI, ~80kVp)

Original

process-code #2 "2.1b"

process-code #6 "2.1b+2.1c"

process-code #7 "2.1a+2.1b+2.1c"

2.3. Non-working "Example1.DCM" (older low-end TFT 43x43cm, 3268x3268, GadOx, ~80kVp)

Original

tried to process

It doesn't match "1.1b)" (then global area's detection on right lung fails miserably). By menu "Analyze>Plot Profile" in ImageJ one could ensure that lungs' cupolas are far less prominent here against "Example0" (DQE($0_{1/mm}$) here is too small).

3. Detailed description

3.1. Install ~recent ImageJ's release

I wrote the macro-script with recent deployment archive in https://imagej.nih.gov/ij/download.html (1.53k for Java SDK 1.80, Windows 64). I don't know which earliest ImageJ's release suits today's built-in macros. Fortunately, refresh or recent ImageJ is easy:

step 1) Locate existing ImageJ's directory (let's call it as "`C:\Program Files\ImageJ\`").
step 2) Rename that directory as "`C:\Program Files\ImageJ.1\`".
step 3) Download and decompress recent ImageJ's deployment archive as "`C:\Program Files\ImageJ\`".
step 4) Ensure that old desktop's shortcuts to ImageJ (if such ones exist) work.

3.2. Deploy the utility to PC (to hard-disk)

It needs CPU with AVX2. It excludes mostly notebooks with exotic Xeons and old desktops (exe-process dies silently).
Decompress deployment archive as "`C:\ImageJRibCage\`". The directory is fixed in macro-script. If you misprint the name then macro-script displays additional dialog (when locating exe). To remove utility from hard-disk (in a future) just delete the directory "`C:\ImageJRibCage\`".

3.3. Suggested feasibility-test

step 1) Open "`C:\ImageJRibCage\Example0.DCM`" and glance/analyze profiles' shapes, statistics. If yours working images are far different then remove the utility from hard-disk.
step 2) Start ImageJ. Click "Plugins>Macros/Edit" and browse for "`C:\ImageJRibCage\RibCage.ijm`". Macros-window (titled "RibCage.ijm") with macro-script appears.
step 3) Click "Macros>Run Macro" in menu of the macros-window. In appearing dialog-box click [OK]. Wait 10..40s. Consider new image-window (titled "$3268x3268.raw"). If it looks meaningless then remove the utility.
step 4) Open "`C:\ImageJRibCage\Example1.DCM`" and glance/analyze profiles' shapes, statistics. If your working images are more near to "`Example1.DCM`" than to "`Example0.DCM`" then remove the utility.

3.4. Suggested test of the options

step 1) Open macros-window "`C:\ImageJRibCage\RibCage.ijm`".
step 2) Open a chest-radiography (within constraints "**1.1**").
step 3a) Click "Macros>Run Macro". In appearing dialog-box unselect options #1, #4 (#2 selected). Enter suffix like "_2" and click [OK].
step 3b) Set original image-window as current again. Click "Macros>Run Macro". In appearing dialog-box unselected #1 (#2, #4 selected).
Enter suffix like "_6" and click [OK].
step 3c) Set original image-window as current again. Click "Macros>Run Macro". In appearing dialog-box enter suffix like "_7" and click [OK].
step 4) Consider suitability of image-windows "$wwwwXhhhh_2.raw", "$wwwwXhhhh_6.raw", "$wwwwXhhhh_7.raw".

3.5. Apagogical “indirects“

3.5a) Among general concepts, this approach is an opposite to convolution networks (to deep learning specifically): here are fixed algebraic filters.

3.5b) The specific among other fixed filter is reliance on ~linearly dependent coordinate-axis and laplacians’ modulation in a way opposite to Gabor-transform. Here is nothing like component analysis; even not a single “list-structure” is in use.

3.5c) Typical RibCage-subtraction approaches achieve <*try to*> higher quality of diagnostic by relatively small increase of radiographer’s work:

- clean <as one could> subtraction of RibCage (that collaterally changes lung-pattern of alveolus and small vessels);
- then radiographer sees more nodules, tumors on subtracted image; but then he reviews the original with ~the same attention for lung-pattern’s issues.

3.5d) This approach <tries to> reduces radiographer’s work for the ~same quality of diagnostic:

- the target is subtraction of RibCage while ~lung-pattern keeps visually;
- then radiographer views subtracted image with less fatigue (perhaps in smaller zoom) and reviews the original with max attention to suspicious areas (if subtracted image has those).