NCCPM Tools for DBT QC
nccpmToolsRelease_1.01

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1 Introduction

The National Coordinating Centre for the Physics of Mammography (NCCPM) has developed some software to assist in the analysis of tomosynthesis images acquired for QC as described in the draft NHSBSP Physics QC protocol for breast tomosynthesis. These tools have been packaged together as an ImageJ plugin. This document gives details of the tools and how to use them. Those wishing to use these tools should first of all verify that they satisfactorily perform appropriate analysis on their QC images.

2 Description of the tools

2.1 Slice Hack

The standard DICOM format for DBT images is the BTO format, which consists of a single file which can be loaded into DICOM viewer software, making the individual slices available for analysis. However if one wishes to use other software, such as CDCOM, which was designed for use with 2D DICOM images, then the required focal planes need to be extracted from the BTO file and stored in a 2D format. This may be done using the NCCPM tool Slice Hack.

2.2 Flatfield

This tool may be used where necessary to reduce low frequency non-uniformities in CDMAM images prior to reading using CDCOM. The method of flatfielding is as follows: Each image is cropped close to the useful area of the CDMAM and padded out to achieve an image size with dimensions equal to the nearest power of two. A Butterworth filter is applied in the frequency domain to remove the higher frequencies including the grid and contrast details of the CDMAM. The parameters of the Butterworth filter are a forth order filter with a cutoff of 5mm. The original image is then divided by the filtered image and the pixel values rescaled.

2.3 Geometric Distortion

The location of each ball is found by moving a small ROI around within the search area and recording the position in terms of focal plane number and x,y coordinates within the plane at which the standard deviation of the pixels within the ROI is greatest.To find the FWHM of a ball within the plane of best focus, the maximum pixel value from each column is taken, giving a single row of pixels. These are background corrected and a polynomial spline fitted to obtain a FWHM. The process is repeated in the orthogonal direction, taking the maximum pixel value from each row. To measure a composite FWHM in the x and y directions taking all planes into consideration, a composite plane is created using the maximum pixel value from all planes. This is then reduced to a single row or column as above to obtain composite FWHM in the x and y directions. To measure a FWHM in the vertical direction, the stack of focal planes is re-sliced in the vertical direction and the processes described above repeated to five a FWHM in the z direction.

2.4 Virtual and Partial Dicom Opener

Due to the large size of Tomosynthesis files loading the full images on low power machines may not be possible. To address this issue we have created two plugins that can load large DICOM files while using a low amount of computer RAM. Virtual Dicom Opener can loads each slice of the image into memory as it is requested. The speed of analysis and other features will be reduced and is dependant on the access to the file. Partial Dicom Opener can open a reduced number of slices directly into RAM. This will be faster than Virtual Dicom Opener but will not allow access to all of the slices.

3 Instructions for use of tools

3.1 Installation of plug in

Ensure that the PC has installed Java 6 or later and ImageJ v1.4.6 or later. Save a copy of the file containing the tools (nccpmToolsRelease_1.00.jar) to "C:\...\ImageJ\plugins". Only one .jar file can be stored in this location for use by ImageJ. When ImageJ is opened the NCCPM tools will be found in the menu under the Plugins tab.

3.2 Slice Hack

Slice selection: When Slice Hack is selected a dialogue box asks the user to enter the range of the slices to be extracted (the first slice in the BTO file being zero). Next, a dialogue box opens in which the user identifies

the folder containing BTO images from which the slices are to be copied.

Output: The tool creates a folder labelled MammoX (X being the slice number selected) containing the copied slices in the same folder. The tool will attempt to copy the nominated slice from all files within the indicated folder, and if it comes across a file from which the slice cannot be copied then an error is generated and the process will stop.

3.3 Flatfield

Image cropping: The user opens the first image in the folder and draws a rectangular ROI around the CDMAM grid, allowing a small margin for phantom shift between images. The Flatfield tool is then selected from the Plugins menu.

Output: All images in the same folder will be flatfielded, using the same rectangular ROI defined in the first image, and stored in a subfolder labelled Flat. If the CDMAM moves too much between images, then it may be clipped in some of the flatfielded images, in which case it may be necessary to redefine the rectangular ROI and redo the flatfielding for some of the images.

3.4 Geometric Distortion

Stack creation: Open the reconstructed image to be analysed using ImageJ using one of the following methods:

- For images in CT format: Drag and drop an image in CT format (folder containing separate focal planes) onto the ImageJ toolbar, and open as a stack.
- For slices in separate files:

  Drag and drop a selected range of slices onto the ImageJ toolbar, and then when these have opened as separate image, convert to stack using Image / Stacks / Images to Stack.

  Or

  File / Import / Image Sequence and select first file in the folder. A dialogue box will then ask for the number of images required and the starting image.
- For images in BTO format:

  Drag and drop the image file onto the ImageJ toolbar.

  Or

  File / Open and select image file.

  The scrollbar at the bottom of the image can be used to scroll through the focal planes. If the planes were loaded from an

image in CT format, there is a possibility that the planes will be in the wrong order as ImageJ loads the images in numerical order, which may not be appropriate depending on how the files are named.

ROI initialisation: To use the Geometric Distortion tool, open the image, draw a small rectangular ROI around the top left ball of the group to be analysed, and select the NCCPM tool. [1] A dialogue box will ask for the size of the array of balls to be analysed and the distance between balls in the test phantom used. Results are produced for each ball, starting at the top of the image and moving left to right:

- X-FWHM for the single plane of best focus in mm
- Y-FWHM for the plane of best focus in mm
- Composite X-FWHM using maxima from all planes in mm
- Composite Y-FWHM using maxima from all plane in mm
- Composite Z-FWHM using maxima from all plane in slices[2]
- Slice number at height of best focus
- X coordinate of the ball in pixels
- Y coordinate of the ball in pixels
- Mean background pixel value around the ball in plane of best focus

If the user rejects the option of further analysis, this data for individual balls can be selected and pasted into Excel for user analysis.

Post analysis: Alternatively the user may accept the analysis option and obtain the following:

- Average distance between balls in adjacent columns (x separation) in pixels
- Maximum percentage deviation from this average x separation
- Percentage scaling error in the x direction using pixel spacing from DICOM header
- Average distance between balls in adjacent rows (y separation) in pixels

[1] Beware of performing analysis on balls close to the edge of the image where edge effects may distort the FWHM measurement. The background value for a suspect ball should be checked to ensure the background ROI has not overlapped the edge of the image.

[2] Currently available systems have a focal plane separation of 1mm. If a system is encountered where this is not the case, then the Z-FWHM would need to be multiplied by the focal plane separation to get the result in mm.

- Maximum percentage deviation from this average y separation in pixels
- Percentage scaling error in the y direction using pixel spacing from DICOM header
- Average slice number for all balls
- Maximum deviation in slice number
- Mean FWHM in the vertical direction for all balls (slices)

Further analysis: The user may wish to try the following ImageJ functions, to check or as an aid to understanding the operation of the Geometric Distortion tool:

- Reslice the displayed image stack in the vertical direction: Select a region of the image using a rectangular ROI (optional) then select Image / Stacks / Reslice.
- Create a composite image consisting of the maxima from each plane: Select a region of the image (or resliced image) using a rectangular ROI (optional) then select Image / Stacks / Z Project.

3.5 Virtual Dicom Opener

Running the plugin will prompt the user to select the large single DICOM file. The image will then load.

3.6 Partial Dicom Opener

After being prompted for the file the user will be asked to select a range of slices. These slices will be loaded into memory and the image loaded.