IQWorks Analysis Tree for Measurement of Square Wave Contrast Transfer Factor in Mammography

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Introduction

Square Wave Contrast Transfer Factor (SWCTF) is a parameter used to assess detector resolution in full field digital mammography systems. SWCTF at a given frequency is calculated as described in Equations 1 and 2. IQWorks is a software package that allows analysis of test images through the construction of an automated analysis tree. The aim of this study is to construct an IQWorks analysis tree that can automatically calculate the SWCTF from a test image of the resolution grating test object. The SWCTF will be calculated using the first and thirteenth bar group in both the horizontal and vertical sets. The first bar group has a bar pattern frequency of 1 line pair per millimetre (1 lp/mm) and the thirteenth bar group has a bar pattern frequency of 4 line pairs per millimetre (4lp/mm). IQWorks has the ability to rotate images prior to analysis. Images have been rotated so that straight edge of the test object is parallel to the left hand side of the field of view.

Method

Figure 1 shows a schematic view of an analysis tree created to calculate SWCTF using an image of the TOR max phantom. The tree consists of an edge detection algorithm that can detect the edge of the TOR Max phantom and also the edge of the resolution bar group sets. Regions of Interests (ROI's) are then automatically placed in accordance with the test protocol described in NHSBSP Report 0604 and a series of simple math modules calculates the SWCTF at multiple different spatial frequencies described above. A PDF report is then produced displaying the results of the test. Figure 2 shows a screen shot of the analysis tree applied to a test image of the TOR Max phantom. The robustness of the analysis tree has been tested by applying the tree to test images acquired under the conditions described in the test protocol from thirteen different mammography units. Results produced by the analysis tree have been compared with those acquired by manually using the ROI analysis tool at the console workstation.

$$M_0 = |M_S - M_B|$$

Equation 1. M_0 is the object amplitude. M_S is the pixel value relating to the least attenuation region in the test piece. M_B is the pixel value relating to the most attenuating level in the test piece.

$$SWCTF(f) = \frac{M(f)}{M_0}$$

Equation 2. M(f) is the standard deviation of the pixels in a region covering the bar group at bar pattern frequency f.

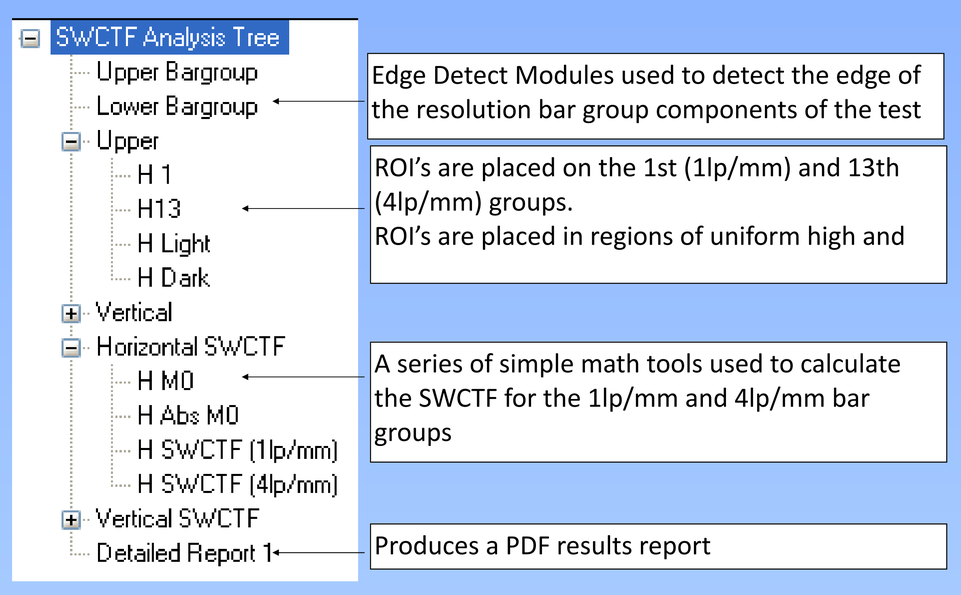

Figure 1—Schematic of analysis tree created to calculate SWCTF for both sets of bar groups in both the horizontal and vertical gratings. The vertical components of the analysis tree have been minimised for illustration.

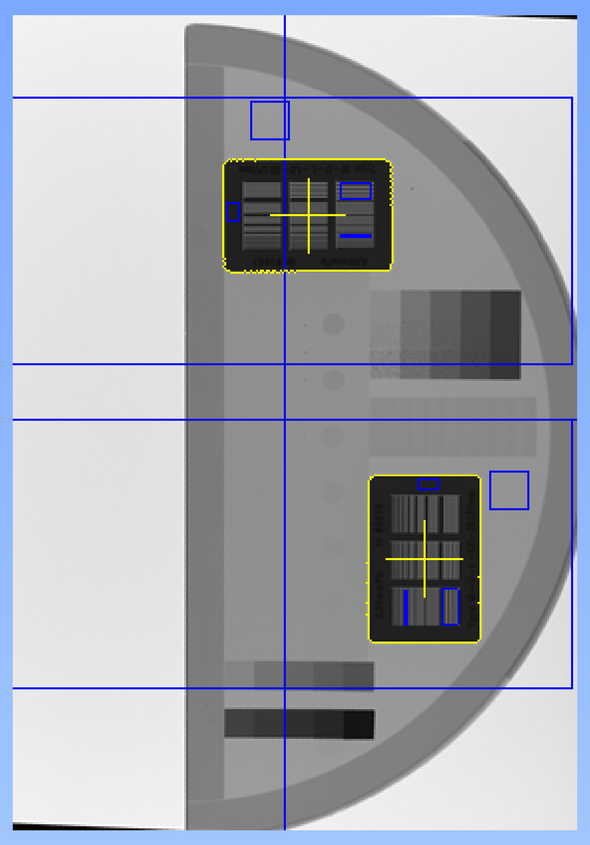

Figure 2—Screen shot showing the analysis tree applied to an image of the test object. Yellow lines indicate bar group sets detected by the edge detect modules and blue lines represent ROI's automatically positioned relative to the detected bar group sets.

Results

A comparison in SWCTF results have been made between those acquired by using the IQWorks analysis tree and those acquired during survey using the console ROI tool. SWCTF's have been calculated for the different bar groups as described above. The R^2 value has been calculated for the relationship between results acquired for each method and is shown below. Figure 3 shows a scatter plot comparing the IQWorks analysis tree and survey results for SWCTF calculation using the horizontal bar group containing 4 line pairs per mm.

Bar Group	R^2
Horizontal 1lp/mm	0.866
Horizontal 4lp/mm	0.942
Vertical 1lp/mm	0.947
Vertical 4lp/mm	0.916

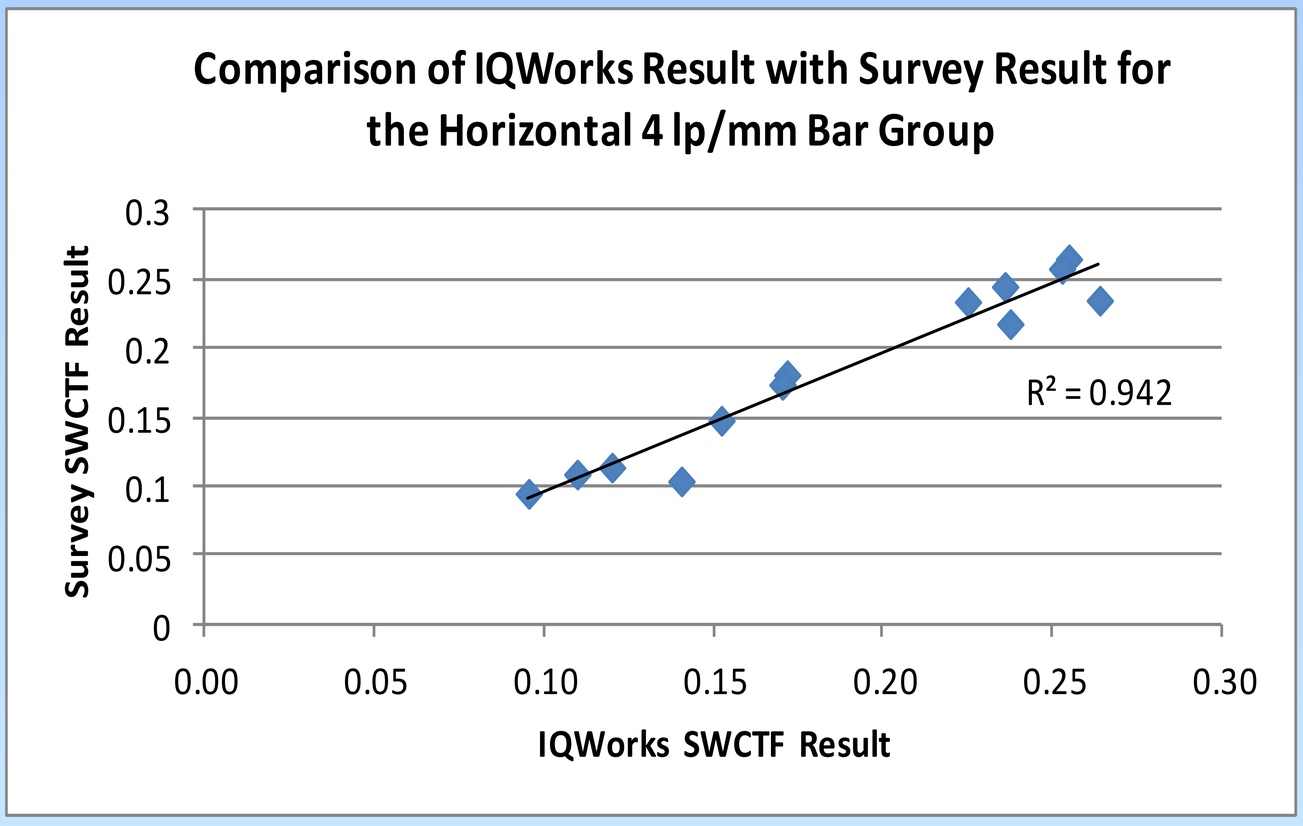

Figure 3—Comparison of IQWorks SWCTF result with SWCTF result acquired during survey by using ROI tools at console work station. Graph shows a good agreement between both methods.

Discussion

There is a good relationship between the results produced by the IQWorks analysis tree and those using the analysis tools at the console workstation which suggests that the analysis tree is sufficiently robust to use for image analysis. Automated analysis reduces the time required to analyse images and automatic ROI placement removes potential error in ROI placement. The biggest challenge in creating an analysis tree is finding an edge detection algorithm that can successfully detect the edge of the phantom and the test object components in each image.

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