Automated ACR Image Analysis for MR Imaging for All Seven Tests

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Background

For a medical physicist, an American College of Radiology (ACR) image analysis for magnetic resonance imaging (MRI) must be performed annually. For the physicist to make measurements on these images, they must use image analysis software to make subjective measurements that follow the ACR phantom guidelines. Depending on the institution, the physicist may be required

Methods

MATLAB code (created with MATLAB R2017b, including the Image Processing Toolbox) was used to program automatic evaluation of all tests in the Phantom Test Guide for ACR. The program also does a signal-to-noise (SNR) as a function of image gap analysis. The phantom is positioned along the z-direction according to the manual for the ACR MRI accreditation phantom. The algorithm sorts the images by slice number. The algorithm will correct for any rotation in transverse plane. The total execution time for the three tests was on the order of seconds. The images were acquired on a Siemens scanner, which stores each slice as an individual DICOM file.

Results

For all tests for BCH algorithm are within 2% of the manual measurements, better than the existing software.

Conclusion

This study has shown that the MRI ACR test can be automated with the entire program running in 5 seconds. It can assist with the manual method of taking measurements. And this MATLAB program can be distributed for free instead of the institution purchasing a more costly program. I have shown that our results are comparable to those of an existing MRI ACR image analyzer and is more precise than existing software.
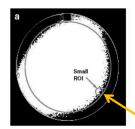

Image of slice 7 showing windowing of image and placement of small 1 cm² ROIs for image uniformity measurements.

Image of slice 5 with diameter measurements with arrows

Image of slice 7 illustrating ROI placement for percent-signal ghosting measurements

Image of slice 11 showing the circle of low-contrast for low-contrast object detectability test

Slice 1 with diameter measurements illustrated (left). Localizer with end-to-end length measurements (right).

Slice 1 with the slice thickness insert and signal ramps indicated and magnified region.

Images of slice 1 and 11 measuring position error. The arrows indicate the bar length difference measurement that is to be made.

```
widthLat: 192.3828
widthAP: 192.3828
difference_Lat: 2.3828
difference_AP: 2.3828
width_localizer: 151.3672
difference_localiaer: 3.3672

dateAndTime: '20190114 080823'
originalImage: [256×256 double]
rampImage: [26×256 double]
sliceThickness: 5.4688
barThicknesses: [5.5664 5.3711]
UpperRampLength: 55.6641
LowerRampLength: 53.7109

originalImage: [256×256 double]
slicethickness: 5
ROIpos: [53.8930 53.8930 157.2140 157.2140]
uniformity: 94.7810
signalIntensities: [1845 1662]

originalImage: [256×256 double]
r: {[1×657 double]  [1×626 dou
maxDeviation: -0.7910
direction: 'NE-SW diagonal'
profileLength: [190.6738 189.2090 189.4531 190.4297]
difference: [0.6738 -0.7910 -0.5469 0.4297]
trueProfileLength: 190

ROI_top: 13.9754
ROI_bottom: 14.9286
ROI_left: 14.5631
ROI_right: 12.9277
ROIpos: [52.8930 53.8930 157.2140 157.2140]
ROImean: 1.7537e+03
ghostratio: 4.0292e-04

longbar_slice11: 31.2500
shortbar_slice11: 30.2734
difference_slice11_accuracy: -0.9766
longbar_slice1: 30.2734
shortbar_slice1: 31.2500
difference_slice1_accuracy: 0.9766

Number of circles visble: 40
Center frequency: 63.6055 Hz
Field Strength: 1.4938 T
Date of exam: (yyyy/mm/dd) 20190114
highest_resolution: [1.1000 1]

=== automaticQualityControl completed ok ===
```