NMQC: NEMA-compliant software for gamma camera quality control

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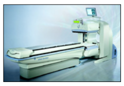
Introduction

The purpose of quality control (QC) tests for nuclear medicine gamma cameras is to detect changes in performance which might degrade the accuracy of clinical images. To avoid image artifacts due to camera malfunction, hospital technicians regularly perform various quality control tests — some daily, others weekly, monthly or yearly. After acquisition, the data is checked visually and, in parallel, analyzed by specialized software to generate statistics characterizing camera performance. In order to standardize these tests and to allow for comparison of the performance of different cameras, the National Electrical Manufacturers Association (NEMA) has compiled a document which describes how to perform and report scintillation camera QC tests. The latest NEMA standard, NU-1 2001 [1], contains both instructions for how to perform QC experiments and guidelines for analyzing the resulting data.



Contribution: We have developed a software application which implements the basic scintillation camera QC analyses as described in the most recent NEMA standard. Our software allows multiple types of QC test data to be analyzed within a single application, and enables the comparison of different cameras in a uniform way. Thus our application complements manufacturers' software (which performs similar functions for specific cameras), by providing an independent analysis of data from different camera types and from different manufacturers.

Methods

Software Environment

Our application is written using the Matlab environment, which has several benefits, foremost of which is cross-platform compatibility. Since Matlab runs on Windows, Linux, Mac OS X and Solaris, so does our software. Also, using Matlab as a development environment facilitated creation of this full-featured application in only four months. By installing the free Matlab Common Runtime (MCR), anyone can run our software, even if they do not have Matlab or the Image Processing Toolbox.

NEMA Quality Control Tests

Our application implements all of the basic nuclear medicine camera QC tests. These tests cover the most important areas for evaluation of gamma camera performance: uniformity, resolution, and rotational alignment. Measurements of these properties are performed as part of daily, weekly or periodical QC tests. [2] [3]

Planar Uniformity

Planar uniformity tests are designed to detect spatial non-uniformities in the camera response which might later cause reconstruction artifacts. This test is performed daily using a flood source, and measures the variations across the detector face.

Uniformity = (max-min) / (max+min)

Profile Analysis

To test camera resolution, sources are placed at a known distance from the detector, and the Full Width at Half Maximum (FWHM) and Full Width at Tenth Maximum (FWTM) of their images is measured. This test can measure planar or tomographic (reconstructed) resolution.

Center of Rotation (COR)

For proper tomographic reconstruction, the relationship between the physical center of rotation of the camera and the center of the projection images must be known. From images of a point source taken during an entire camera rotation, the mechanical deviation of the Center of Rotation can be measured. Smoothness of sinogram and linogram can be checked.

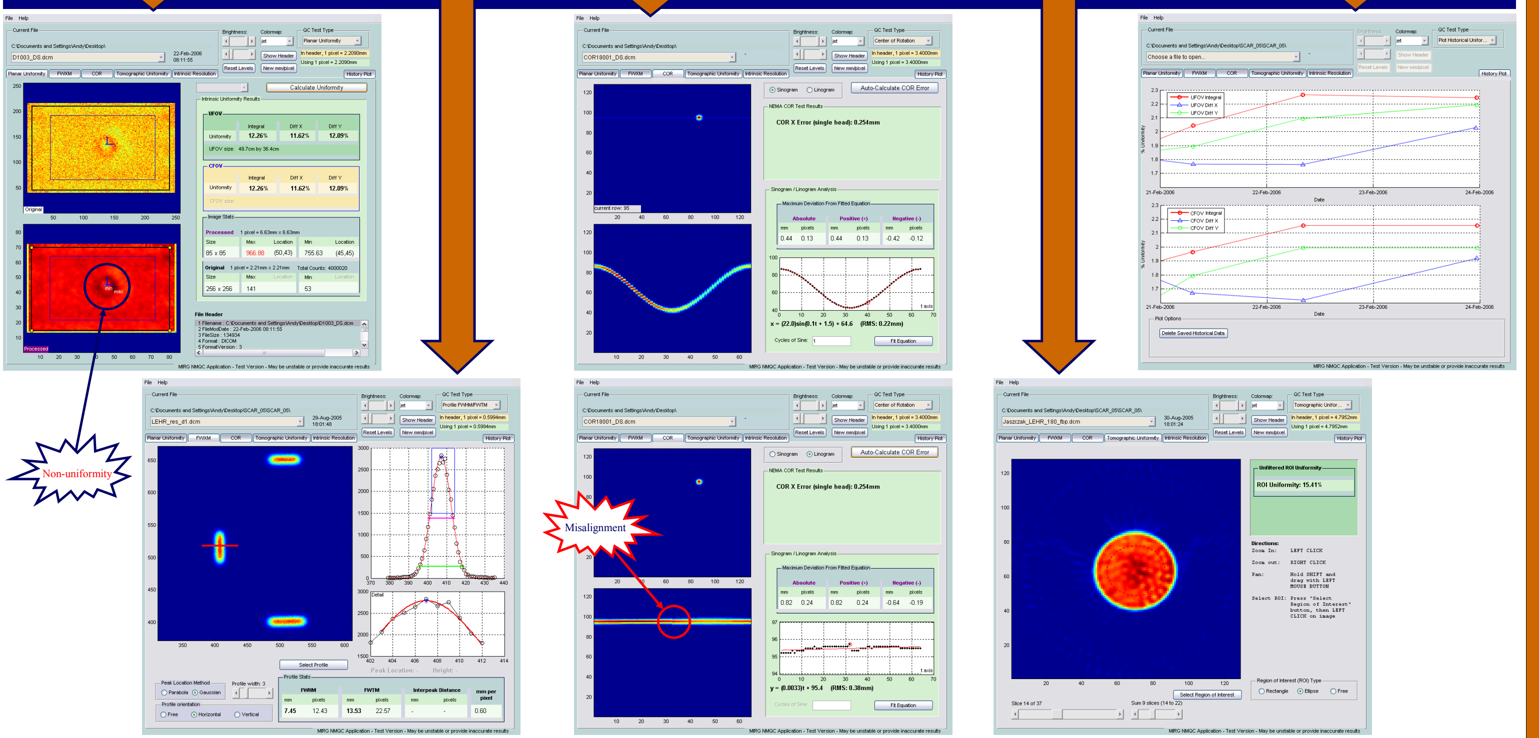
Tomographic Uniformity

Tomographic systems must be subjected to the same basic quality control program as planar cameras. Our software calculates uniformity for differently shaped regions of interest, and allows the summation of tomographic slices for analysis purposes.

History

Our software keeps track of changes which may occur in the planar uniformity values, and allows the graphing of uniformity statistics over time.

Results



Discussion

Because of the frequency of QC tests, it is important that the analysis be simple and straightforward. Further, numerical test results are very useful for accurate evaluation of camera performance. Our software meets both of these requirements. By providing analysis which is both independent of and complementary to manufacturer's proprietary software, our program gives a useful overview of a camera's current performance. Additionally, by allowing the user to plot test results versus time, gradual degradation in performance can be detected. Also, data from cameras of different brands can be used as input to our program and analyzed in a uniform way, allowing a fair comparison of different cameras' performance. Our software is currently being validated at the Vancouver General Hospital Department of Nuclear Medicine.

Conclusion

We have implemented a cross-platform application for analyzing gamma camera quality control data according to NEMA standards. By leveraging the Matlab development environment, a useful application with a full GUI was developed in a short time. This software performs all of the basic quality control tests necessary for planar and SPECT scintillation cameras. Our application is easy-to-use, cross-platform, and serves as an independent complement to gamma camera manufacturers' proprietary quality control software. Future plans for the software include implementation of NEMA PET QC tests and porting to an object-oriented programming language.

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References: [1] NEMA NU-1 2001: Performance measurements of scintillation cameras. National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia, USA. http://www.nema.org/stds/nu1.cfm

[2] Groch, M. W. and Erwin, W. D. Single-photon emission computed tomography in the year 2001: Instrumentation and quality control. Journal of Nuclear Medicine Technology Volume 29, Number 1, 2001 12-18

[3] Hines H., Kayayan R., Colsher J., Hashimoto D., Schubert R., Fernando J., Simcic V., Vernon P., and Sinclair RL. National Electrical Manufacturers Association recommendations for implementing SPECT instrumentation quality control. J Nucl Med Tech 1999;27(1):67–72.