Leader: Heather Shumaker **BSAC:** Sam Brenny **Communicator:** Connor Ford **BPAG & BWIG:** Rachel Reiter

Abstract

Computed tomography (CT) machines are tested regularly to ensure the machines are calibrated and functioning properly. After each test, a report is generated featuring the results and testing protocols. The report is given to service engineers who adjust the machines based on the test results. In order to expedite and standardize CT quality assurance testing, a software program will be created to accept user input, automate calculations and CT image analysis, and generate testing reports. This program will consist of a graphical user interface created in MATLAB and will help to reduce communication issues as well as significantly decrease the time and effort involved in CT quality assurance testing.

Client Information

Professor Tim Szczykutowicz

Assistant Professor at UW School of Medicine

- Radiology, Medical Physics, and BME departments
- Interested in optimizing CT scan protocols, dose monitoring, & protocol management methodologies [1]

Motivation

- No standardized protocols for CT quality assurance \rightarrow inconsistency and miscommunication
- Miscommunication can delay CT system adjustments
- CT quality assurance (QA) testing and reporting takes hours
- Measurements taken & computed by hand = room for error

Background

Computed Tomography (CT)

- X-ray images from multiple angles are combined to create cross-sectional images through digital computer processing [2]
- Provides info regarding the anatomy and structure of human tissue [3]
- CT scans applies radiation doses to the patient [4]

CT Quality Assurance

Tests to assess machine functionality

- Performed regularly on daily/weekly/monthly/yearly basis [6]
- Multiple tests to assess certain machine functionalities [7]
- Image phantoms are used to evaluate CT machines [8]

Competing Devices

Image Owl & PIPSpro [9,10]

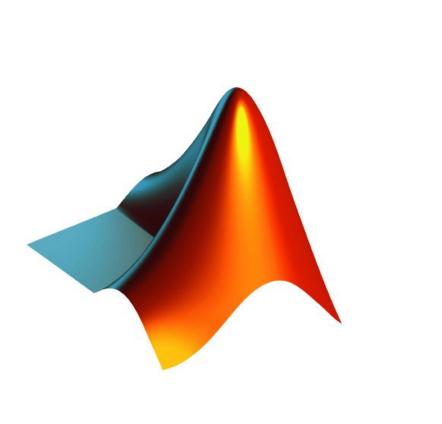
- ✓ QA database & trending
- Automatic image analysis &
- calculations
- Cloud-based service
- **High cost**
- **K** Expensive Customization
- Complexity requires training to use

Design Criteria

MATLAB[®] Graphical User Interface (GUI)

Capabilities include:

- Automatic calculations
- Automatic CT image analysis
- Store and manipulate user input
- Generate report based on measurements
- Display CT machine trends
- Export PDF of testing report

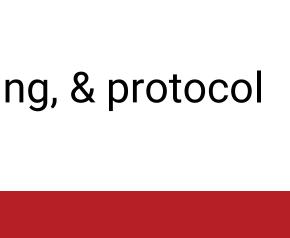


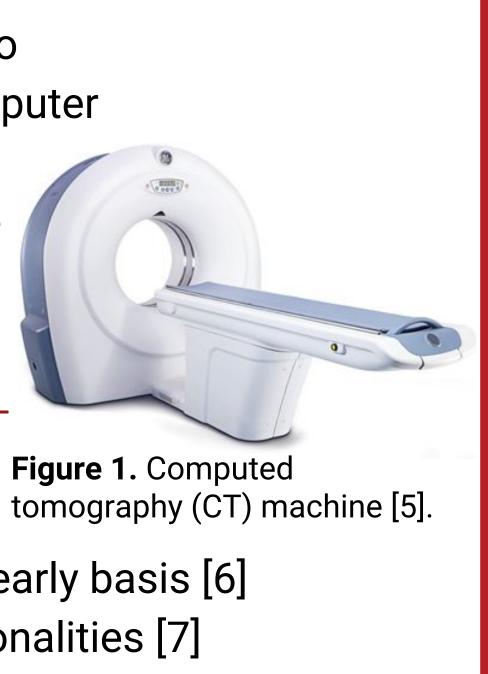
Automated Quality Assurance System for Clinical CT Systems Client: Prof. Tim Szczykutowicz, Dept. of Radiology Advisor: Prof. John Webster, Dept. of Biomedical Engineering BME 400, Dept. of Biomedical Engineering University of Wisconsin – Madison, WI 53706 Final Design Final Design Materials **CT Uniformity Panel** Place ROIs MATLAB[®] software licensed by MathWorks[®] LaTeX document preparation system Figure 4. The CT Uniformity panel allows the user to create Methods regions of interest (ROIs) on a image from the Program was divided into individual testing panels The code calculates • Each team member worked on testing panels separately the standard deviation of the values of each pixel inside the • All individual code was combined into single GUI ROI. • Report & PDF capabilities added to finished program **Final Prototype** FORT VCT 2016 ACR ANNUAL.t MATLAB GUI consisting of 13 panels - one for each QA test iocumentclass[]{spie} documentclass[conference]{IEEEtr epackage{graphicx} epackage{floa package{caption • Panels include: Basic Information, Safety, Artifacts, Noise, CT Number, CT epackage{enumiter eclareGraphicsExtens epackage{subfigure Uniformity, LCD, Beam Width, Gantry Tilt, Monitor, Protocol Review, Dose, epackage{amsmat package{booktab ommand{\ben}{\begin{eqnarray}\displaystyle and Slice Width command{\een}{\end{egnarray} wcommand{\et}{\emph{et al wcommand{\refb}[1]{(\ref{#1})) ommand{\sectiono}[1]{\section{#1}\setcounter{equation}{0 LATEXIL **CT QA** thor{Timothy P. Szczykutowicz, Ph.D., DAB \skiplinehal REPORT Report Date: 10 14 201 esting Date: 10 06 2016 1005 WTMR \ 1 Highland Avenue iversity of Wisconsin-Madison, WI 53705; 716-560-775 ice: 608-263-572 ike the other scanner, so this issue does not need to be addressed in my opin Figure 2. The CT QA report serves as the main source of communication between the **Figure 5.** MATLAB[®] generated text file physicist and service technician in the quality assurance process. output properly formatted for LaTeX use. Software features & capabilities: • Automatic CT image analysis Testing & Results • QA report generated with push of button • Final program will be sent to the client to test functionality and ease of use • Performs calculations from user input • Combines tools from several programs into one • A formal testing protocol is being developed to quantitatively and • Replaces ImageJ & ROI software qualitatively assess program performance and function as well as general • Ability to export a LaTeX compatible text file to create properly user feedback formatted PDF Results from these tests will allow us to improve the user interface of the Algorithms program and add in other desired functionality • Pixel to distance (mm) calculation ROI evaluation Future Work Image angle calculation Extensive testing of user interaction with program ROI - isocenter distance calculation Modifications & improvements based on test results Panel Layout Publish program details in a scientific journal Beam Width Panel Intensity Profile • Distribute program to other facilities CT_QA_Report_Builder Incorporate additional tests & functionality Beam Width Export Beam Widt Please draw a line for the width of beam Acknowledgements man man We would like to thank: 150 200 Beam widths Prof. Tim Szczykutowicz Prof. John Webster (mm): Figure 3. The beam 20.505 13.032 width panel allows the References 7.749 user to calibrate a pixel distance to millimeters. [1] "Faculty and Staff," University of Wisconsin School of Medicine and Public Health. [Online]. Available: Then the user snaps a https://www.radiology.wisc.edu/people/facultyContent.php?vaultID=552 [2] "CT Scan," Mayo Clinic [Online]. Available: http://www.mayoclinic.org/tests-procedures/ct-scan/basics/definition/prc-20014610 line over the dark [3] G. T. German, "Fundamentals of Computerized Tomography: Image reconstruction from projection" Springer 2nd edition, 2009. portion of each strip. An [4] D. D. Cody *et al.*, "Computed Tomography: Quality Control Manual," ACR, 2012. intensity profile [5] "Brivo CT325," GE Healthcare. [Online] Available: http://www3.gehealthcare.in/en/products/categories/computed-tomography#tabs/tab9C3D470D5705481C89D59EE03636D8DF generated to determine [6] S. Mutic et al., "Quality assurance for computed-tomography simulators and the computed tomography-simulation process," Medical Physics 30 (10). Oct. 2003. the width of the dark [7] T.P. Szczykutowicz. "CT Scanner Annual Testing: East Clinic UWHC DHO," UW-Madison Dept. of Radiology. Madison, WI. July, 2016. regions and the beam

width is calculated in

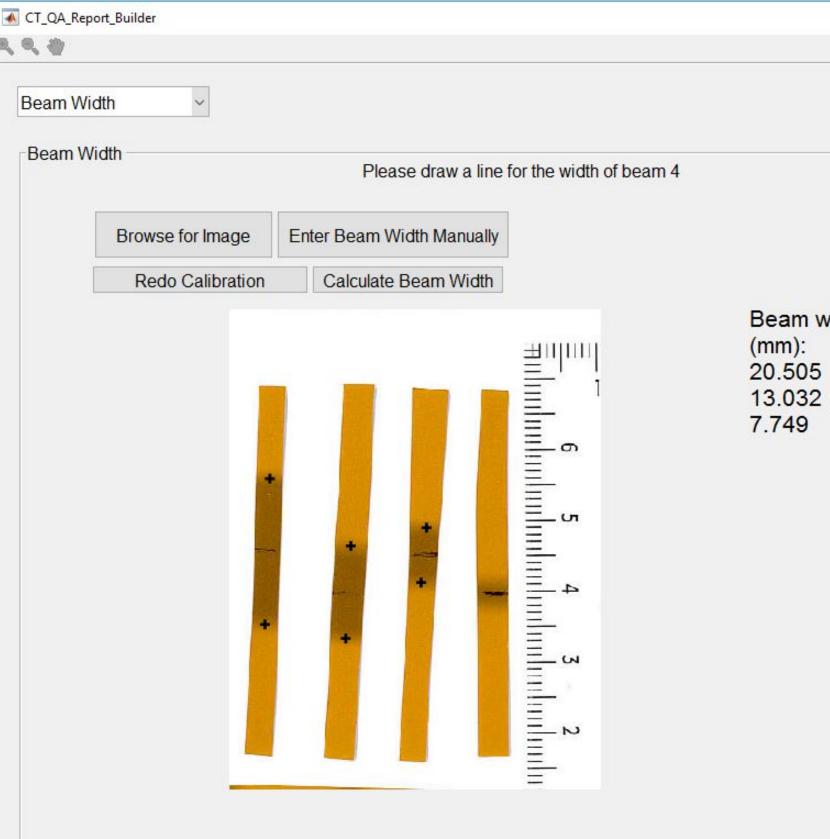
millimeters.

Save

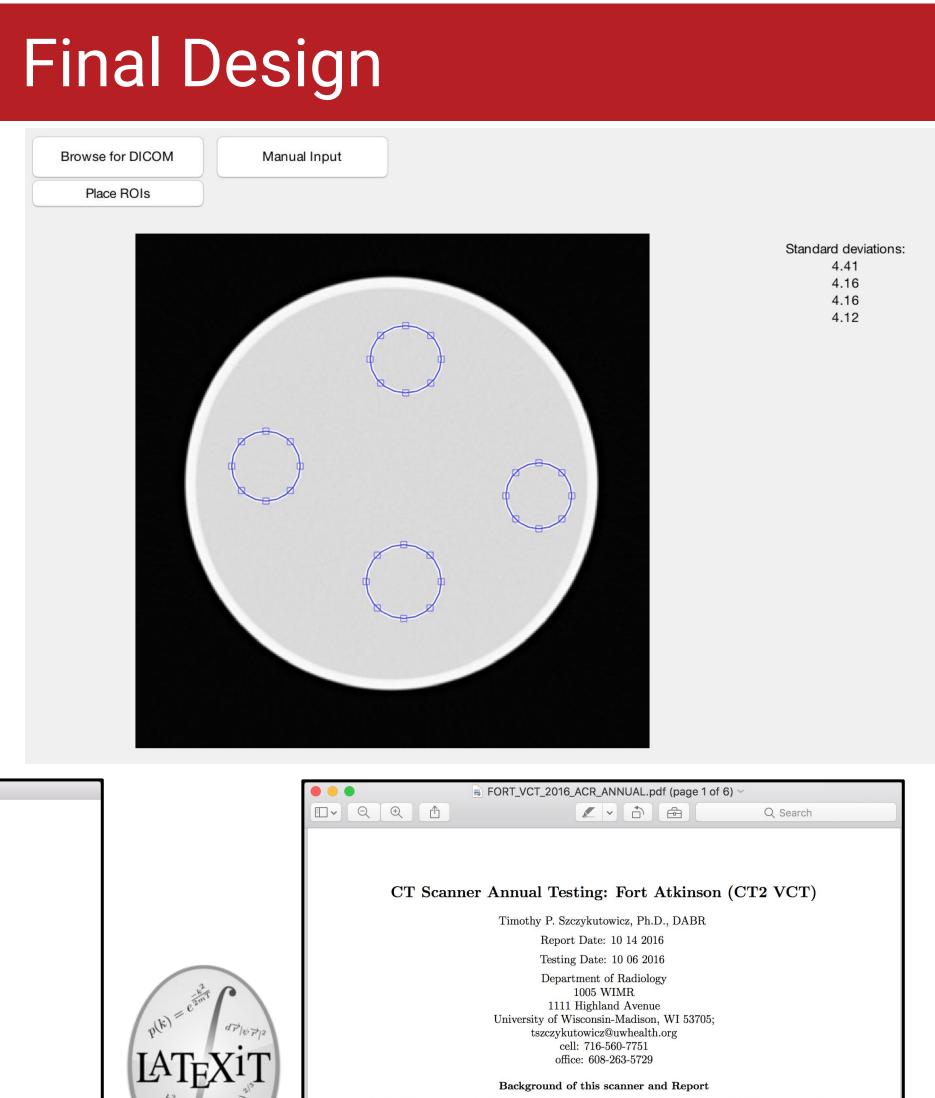




Testing protocols not included in reports







te testing performed was all compliant with AAPM task group report 66 (this report covers CT scar ne RT environment) as well as Joint Commission and American College of Radiology Requirement Two issues were found, the monitor should be looked at by GE service. It has a max lum better monitors are found and this scanner is not used for CT interventional like the other scanner. e does not need to be addressed in my opinion. The second issue is a laser slightly over the 2 mm lim ed by ACR/TG-66. It can easily be addressed by GE service and should be the next time they are i Table 1 lists all test performed and the outcome 2. ARTIFACT The presence of ring artifacts and other artifacts common in CT scanning was assayed using a uniform hantom scanned at a variety of tube potentials, gantry rotation speeds, The scanner did not exhibit any artifacts when technic The CT number ideally should not vary over a uniform phantom. This will only be the case when a unifo object is imaged at isocenter using a bowtie filtration made specific to that object. In reality, this is not the cas ecifies the variation in mean CT number for water is within 7 H Air had a CT number of -1000.53 HU and water 0.86 HU and 4.75 HU standard deviati **Figure 6.** Final report generated by LaTeX using MATLAB^{$^{(B)}}$ generated text file.</sup>

[8] D. J. Goodenough, "Catphan 500 and 600 Manual" Salem, NY. 2006.

[9] "Comprehensive QA Services in the Cloud," Image Owl, Inc. [Online]. Available: http://www.imageowl.com/. [Accessed: 09-Oct-2016]. [10] "PIPSpro Software," Standard Imaging, Inc.. [Online]. Available: http://www.standardimaging.com/qa-software/pipspro-software/. [Accessed: 09-Oct-2016].

UW BME Dept.