Automated Quality Assurance System for Clinical CT Systems

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UW BME Design

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 machine 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 → 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]

Figure 1. Computed tomography (CT) machine [5].

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]**

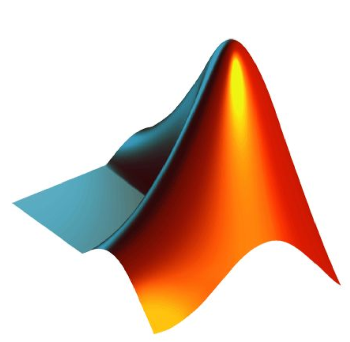
✔ QA database & trending	✖ High cost
✔ Automatic image analysis & calculations	✖ Expensive Customization
	✖ Complexity requires training to use
✔ Cloud-based service	✖ Testing protocols not included in reports

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



Final Design

Materials

- MATLAB® software licensed by MathWorks®
- LaTeX document preparation system

Methods

- Program was divided into individual testing panels
- Each team member worked on testing panels separately
- All individual code was combined into single GUI
- Report & PDF capabilities added to finished program

Final Prototype

- MATLAB GUI consisting of 13 panels - one for each QA test
- Panels include: Basic Information, Safety, Artifacts, Noise, CT Number, CT Uniformity, LCD, Beam Width, Gantry Tilt, Monitor, Protocol Review, Dose, and Slice Width

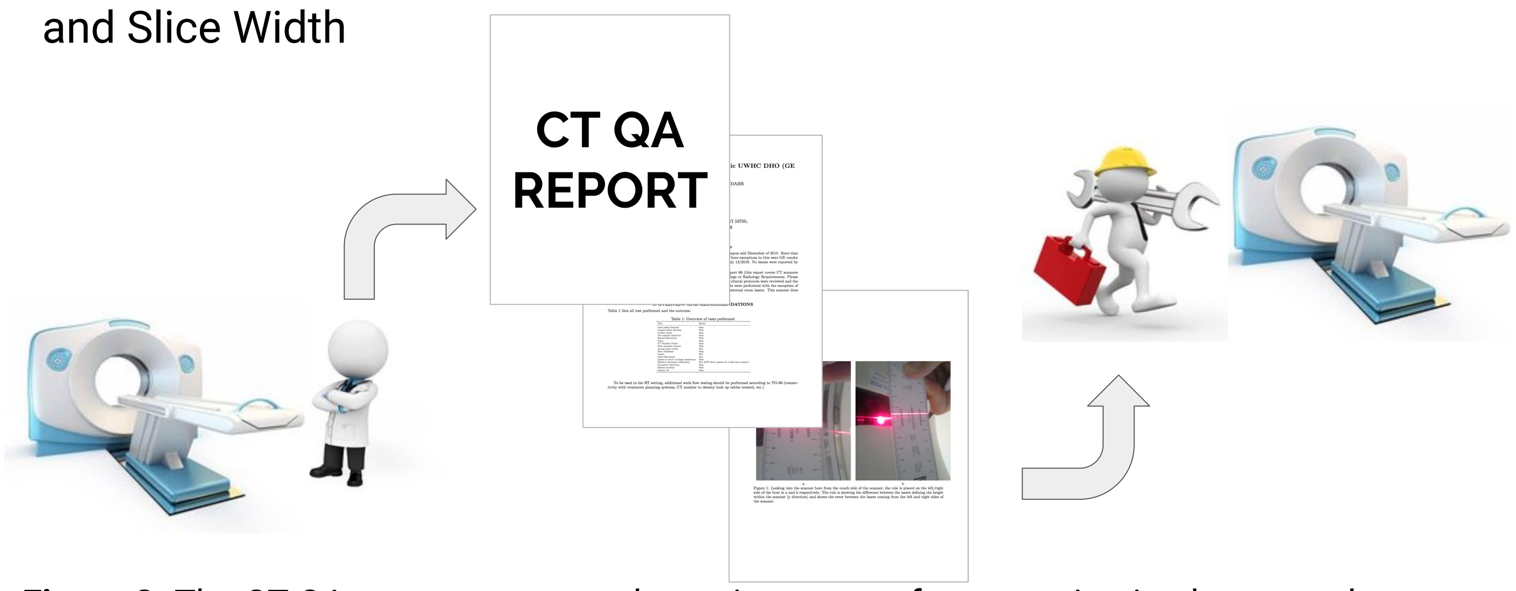


Figure 2. The CT QA report serves as the main source of communication between the physician and service technician in the quality assurance process.

Software features & capabilities:

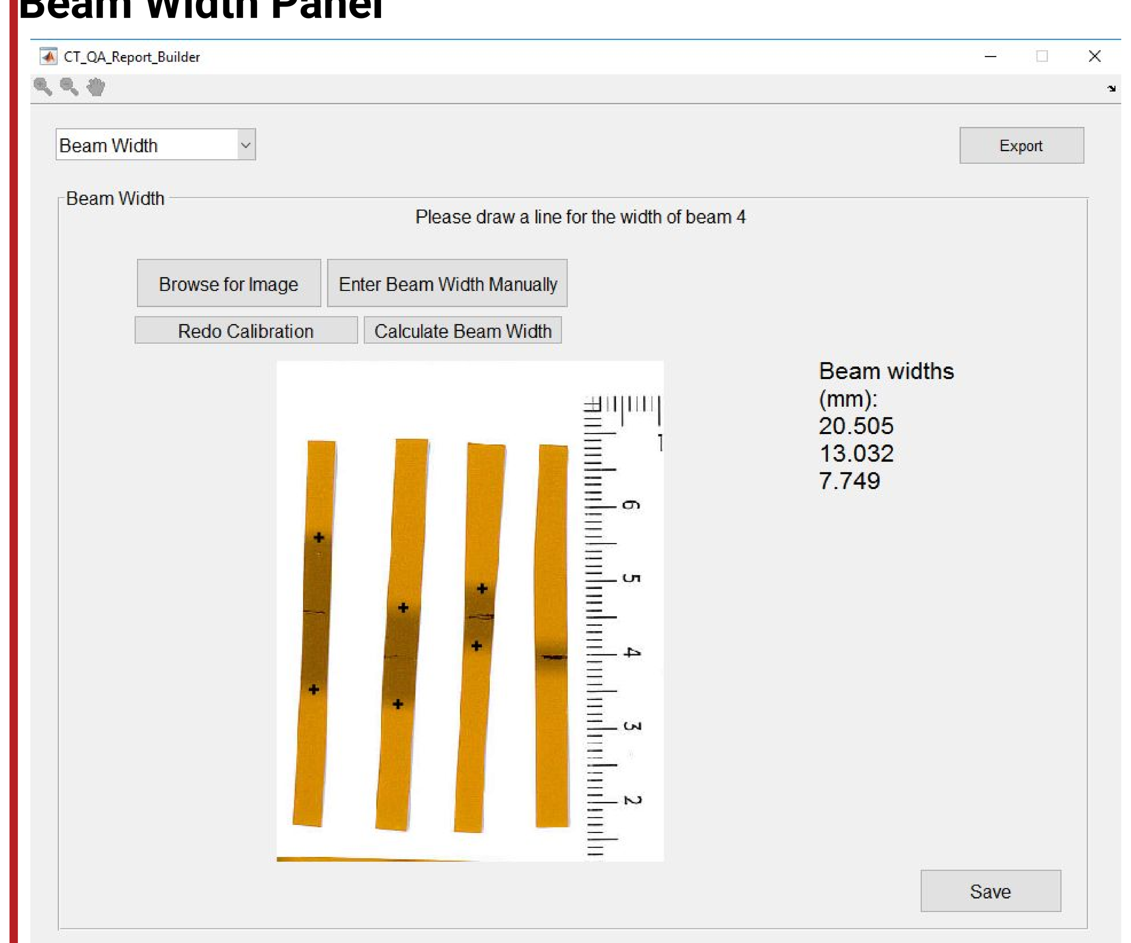
- Automatic CT image analysis
- QA report generated with push of button
- Performs calculations from user input
- Combines tools from several programs into one
- Replaces ImageJ & ROI software
- Ability to export a LaTeX compatible text file to create properly formatted PDF

Algorithms

- Pixel to distance (mm) calculation
- ROI evaluation
- Image angle calculation
- ROI - isocenter distance calculation

Panel Layout

Beam Width Panel



Intensity Profile

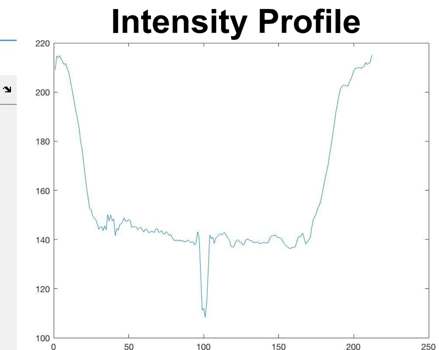


Figure 3. The beam width panel allows the user to calibrate a pixel distance to millimeters. Then the user snaps a line over the dark portion of each strip. An intensity profile is generated to determine the width of the dark regions and the beam width is calculated in millimeters.

Final Design

CT Uniformity Panel

Figure 4. The CT Uniformity panel allows the user to create regions of interest (ROIs) on a phantom image from the testing. The code calculates the standard deviation of the values of each pixel inside the ROI.

Figure 5. MATLAB® generated text file output properly formatted for LaTeX use.

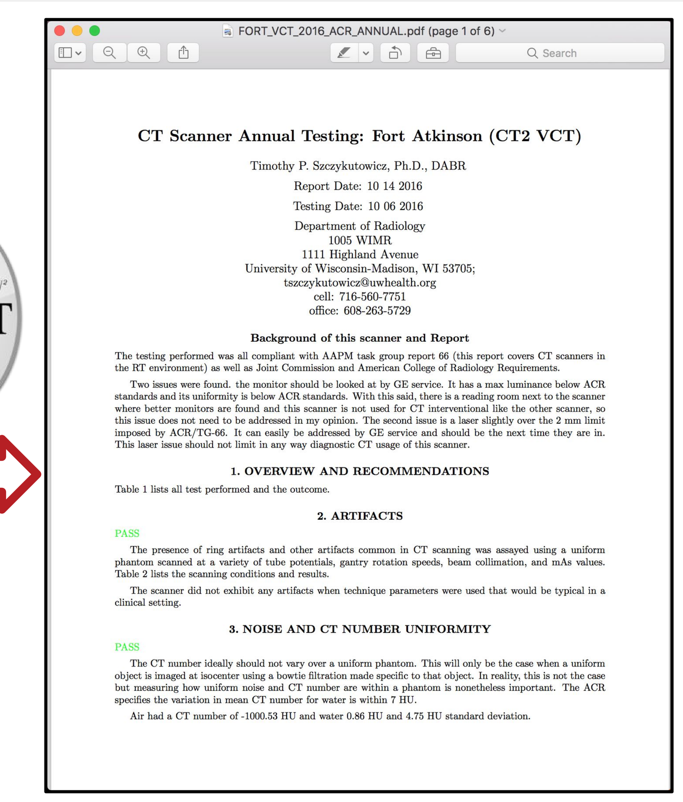


Figure 6. Final report generated by LaTeX using MATLAB® generated text file.

Testing & Results

- Final program will be sent to the client to test functionality and ease of use
- A formal testing protocol is being developed to quantitatively and qualitatively assess program performance and function as well as general user feedback
- Results from these tests will allow us to improve the user interface of the program and add in other desired functionality

Future Work

- Extensive testing of user interaction with program
- Modifications & improvements based on test results
- Publish program details in a scientific journal
- Distribute program to other facilities
- Incorporate additional tests & functionality

Acknowledgements

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References

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