# A New Generation of Quality Assurance for Radiation Oncology

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## 1. Short Statement of Relevance/Purpose

Radiation Oncology medical devices need to be examined monthly to ensure the safety and accuracy of the whole system, and the examination process is called quality assurance (QA). Traditionally, it will take six to eight hours for the medical physicist to do monthly QA, and even longer to do the yearly QA, for the reason that there are many measurement to be done and the physicists need to go inside and outside the operating room very frequently to adjust the position of the measurement device. Dr. John W. Wong intends to accelerate the QA process. He came up with a unifying device for mechanical and dosimetric quality assurance measurements in radiation therapy, which is designed for monthly QA of radiation therapy machines and can measure and record optical, mechanical and radiation data at the same time.

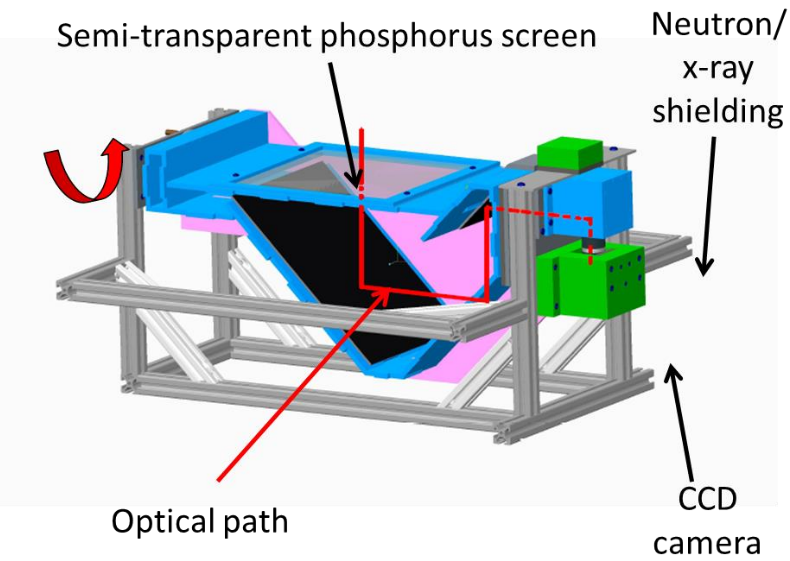


**Fig. 1: The mechanism of the Raven QA Box.**

The mechanism of the device is shown in Fig. 1, and it will be called as Raven QA Box in the following sections. There are three main parts of the Raven QA Box: mirror system, CCD camera, and the motor. The mirror system allows capturing images at the isocenter plane with a stationary camera, and it is fixed once the mechanical engineer has finished the designing job. The CCD camera records the image on real time for analyzing, and the motor controls the orientation of the box allowing it to face the radiation device's gantry anytime, and these two parts need to be controlled by software on the computer.

This project is about the software programming, and the software will be called as Raven QA in the following sections. Raven QA is responsible for four main functions: image acquisition, image processing, motor control and user workflow guidance. In function image acquisition, the software need to access the CCD camera to get different types of image, including changing the shutter time and gain of the camera, changing the size of the image and get background image on real time. In function image processing, the software must calculate the field size, flatness, symmetry and center of mess of the image to give sufficient data to medical physicists for future analyzing. In function motor control, Raven QA reads the data from an inclinometer which is fixed on the radiation device's gantry and controls the rotation stage of the Raven QA box to let it face the gantry at all time. The typical problem of other competitor's devices is a small delay time of the motion. Our goal is eliminating the delay time by employing proper control laws. In function user workflow guidance, Raven QA will give the users support when they are doing monthly QA by showing them the whole workflow and interacting with them when they are doing the job. Raven QA is designed to give users a branch new environment for them working comfortably.

## 2. Technical Approach

First, I will get the access to the CCD camera using the dynamic link libraries provided by Point Grey Research. The following tasks shall be done to accelerate the future development:

a. Build an C# environment to show the live image
b. Get a single 32-bit image and load it from memory
c. Change the gain and shutter time of the camera
d. Get the background of the testing environment

Second, I will control the rotation stage and read data from the inclinometer using the dynamic link libraries provided by Newport, The following tasks shall be done:

a. Buy a proper inclinometer
b. Rotate the rotation stage and get the position feedback
c. Read from the inclinometer
d. Build a control law to keep the rotation stage and the gantry parallel at all time

Third, I will process the images offline. The following tasks shall be done:

a. Draw a line chart according to the greyscale distribution
b. Calculate the field size, flatness, symmetry of the light field images.
c. Add a virtual mask to the image for user inspection
d. Alpha blending
e. Image window adjustment
f. Radiation Isocenter QA

Finally, I will integrate the functions above together and build up a friendly GUI with the whole workflow support. The following tasks shall be done:

a. 3D rendering of the Raven QA box on real time
b. User friendly workflow design
c. Report generation
d. Build an Internet database for users

## 3. Deliverables

Minimum: Image Acquisition, Image Processing, Motor controlling. These three functions are the key structure of the Raven QA. The first release of the software will contain all of them. They must be done.

Expected: Minimum deliverables and 3D rendering, workflow guidance, report generation. These work will enhance the user experience of the Raven QA. 3D rendering allows them to see the orientation of the box outside the operation room, workflow guidance accelerates their work, and report generation allows them reviewing the work in the future.

Maximum: Expected deliverables and Internet database. We hope our users can access to the software everywhere, so an Internet database is needed, and it also marks that all the functions of Raven QA have been done. If time permits, I will submit a conference or journal paper on the motor controlling work.

## 4. Dependencies

a. Money for buying inclinometer
   The inclinometer will be around 1000 dollars. I will search online first to choose a proper inclinometer and discuss it with Dr. Kai Ding. Then we will look for Dr. John Wong to make a final decision and get the funding.
b. Software commercialization
   The software need to be commercialized before the first release. I will consult Prof. Peter Kazanzides. Dr. Kai Ding will help me to write the documents, Esteban and Pat Wong will help me to write the instructions in multi-language.
c. In field validation
   Tests of the software will be run several times before the release. I will test it by myself on every Saturday morning, and make appointment with all the group member for the final test.

## 5. Management Plan

Key milestones are summarized below:

a. February 28: Project plan presentation.
b. March 7: Image acquisition done.
c. March 14: Get the funding for inclinometer, and buy it online.
d. March 21: Motor controlling done.
e. March 28: Reading data from the inclinometer and design the control law.
f. April 4: Real time controlling of the motor using the control law.
g. April 11: Image processing done. (Minimum deliverables achieved)
h. April 18: 3D rendering of the Raven QA box in real time.
i. April 25: Report generation and workflow design. (Expected deliverables achieved)
j. May 1: In field validation, start building the internet database, and start writing the conference paper. (Maximum deliverables achieved)
k. May 9: Poster session.

## 6. Reading list:

1. AAPM (American Association of Physicists in Medicine) (1994) Comprehensive QA for radiation oncology: Report of AAPM radiation therapy committee task group 40. *Med. Phys.* 21:582-618.
2. AAPM (American Association of Physicists in Medicine) (1986) Neutron measurements around high energy x-ray radiotherapy machines. Report 19. AAPM, New York.
3. AAPM (American Association of Physicists in Medicine) (1984) Physical aspects of quality assurance in radiation therapy, Report 13. AAPM, New York.
4. Biggs P., Capalucci J., Russell M. (1991) Comparison of the penumbra between focused and non-divergent blocks-implications for multi-leaf collimators. Med. Phys. 18:753-758.