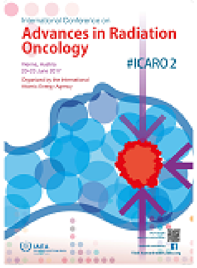

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Film2Dose: an research intended tool to access the combined standard uncertainty on radiochromic film dosimetry using multi-channel optimization.

Thursday 22 June 2017 10:30 (5 minutes)

Introduction:
Modern state-of-the-art techniques in radiotherapy, such as volumetric modulated arc therapy (VMAT), have constantly increased the complexity of treatment delivery and increased the demand for quality assurance (QA) and better small field dosimetry. Dosimetry using radiochromic EBT3 films is a tool sometimes selected to verify the correspondence between planned and measured doses.
A film dosimetry methodology was developed using absorbed dose to water standard and the combined standard uncertainty were also estimated using Scientific Python packages on the software Film2Dose. Figure 1.

Film2Dose software can import many Therapy Planning System formats.

Methodology: Scanned images were measured using calibration films with known doses delivered. The optical density measures were done defining areas of interest of approximately 0.5 × 0.5 cm2 at the centres of the exposed areas. Data was obtained for the red, green, and blue color channels at a resolution of 16 bits/channel and 72 dpi.

$$\mathrm{OD} = -\log_{10}(65535/\mathrm{M}(x))$$

Where M(x) is pixel value from channel x (Red, Green and Blue)
The methodology implemented is optical density based using scanned film images to perform dose measurements. Calibration curves were obtained for each channel using the least squares polynomial fitting. The uncertainty parameterization for each calibration curve was implemented based on literature for type A uncertainty. A methodology to perform multichannel weighted average dose was implemented to estimate Type B uncertainty.

Dose Calculation:
The optical density dx is obtained using a color flatbed scanner for image digitization on red (R), green (G) and blue (B) bands of the visible spectrum. The scanned optical density is defined as:

$$d_X = -\log_{10}(X)$$

Where X [0, 1] stands for the normalized color channel stipulated by the output of the scanner by analog-digital
conversion in 16 bits. The color channel value X also depends on scanner coordinates (i,j), i.e., spatial pixel position.

In accordance with the Beer–Lambert Law, the triple-channel approach can separate numerically the dose-dependent part
of a scanned optical density signal from any disturbance by the equation 3:

$$D_X = \overline{d}_X^{-1}(d_X.\ d)$$

Where the factor $d = \frac{\tau}{\overline{\tau}}$ is the disturbance value and $\overline{d}_X^{-1}$
is the inverse calibration function. This parameter could be interpreted as film relative thickness, artifacts or noise
that modifies optical density values measured by scanner. \

Some functional forms for the sensitometric curve have been proposed on literature. Three different empirical curve
types were chosen to map doses from optical density:

$$d_1^{(n)}(D) = \sum_{n=1}^{3} a_n D^{(n-1)}$$

$$d_2^{(n)}(D) = \sum_{n=1}^{3} a_n \ln(\frac{D}{100} + 1)^{(n-1)}$$

$$d_3^{(n)}(D) = \sum_{n=1}^{3} a_n \arctan(\frac{D}{500})^{(n-1)}$$

Multi-channel dosimetry:
Since the dose cannot depend on the color channel X selected for evaluation of Eq. the Multi-channel approach uses the
information of a sequence of multiple channels $\{X_k\}_{k-1}^{k}$ in a least squares error function of differences between three channels.
A new robust objective function was proposed in order to minimize the film non-uniformity. It is well known that one outlier may cause a large error in a least
squares estimator. In film dosimetry some artifacts might occur more frequently than it was expected in a normal. This work contribution is the implementation of that robust smoothed
objective function in the Gafchromic dosimetry optimization. Then, the robust objective function:

$$\Omega(\ d) = \frac{1}{k}\left(\sum_{i \neq j}^{k} \sqrt{(D_{\mathrm{Xi}} - D_{\mathrm{Xj}})^2 + \delta^2}\right) \rightarrow \min_{d}$$

Results:
Calibration curves from all channels were obtained using a least squares polynomial fitting and their results were evaluated using uncertainty estimation. The standard uncertainty on average dose per region of interest area with approximately 0.5 x 0.5 cm2 was evaluated on recommended dose range (0 - 1000 cGy). Both relative Type A, Type B and combined standard uncertainty values for 1 standard deviation (k=1) behaved asymptotically as function of absorbed
dose to water. Combined uncertainty values were around 20% to 10% on 40-100 cGy dose range, and having an asymptote around
2.5% on doses higher than 350 cGy.

Conclusion:
This work shows that an accessible radiochromic film dosimetry platform can be created using solely open source technologies with statistical confidence and traceability to primary dose to water standards. The uncertainty analysis showed that EBT3 film can access optimum results on doses higher than 350 cGy.

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