



Log file based QA - TomoTherapy

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Disclosure

- Accuray Inc. research collaboration agreement


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Learning Objectives

- Understand different types of Tomotherapy machine log file
- Review implementations of Tomotherapy log file based QA
- Review errors detected via log file analysis
- Understand limitations to log file based approach


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Types of Tomo Log File

- "RawData"
 - Samples at 300Hz (every 3.3 ms)
 - Output, couch position, gantry angle, jaw position, exit detector signal, water temperature, etc.
 - Not archived (overwritten with next treatment)
- "DetData"
 - RawData averaged over n samples (commonly n=10)
- Patient archive
 - Exit detector signal and 3 monitor chamber reading averaged for each projection

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What's missing?

- MLC information
 - One of the major uncertainties of the treatment delivery
 - Non-linear behavior
 - "Latency correction" attempt to correct with a linear model based on a few leaves' behavior




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Detector data analysis I

For projection averaged detector data

$$\text{Detector_data} = \text{Linac_output} \times \text{LeafOpenTime} \times \text{Attenuation}$$

- Assume Linac_output is known
 - monitor chamber reading
- Assume attenuation is known
 - same as CT sim/daily CT or no attenuation (in-air delivery)

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Implementations

- TomoGamma (21st Century Oncology)
 - Lu et.al. SU-E-T-59 AAPM 2011
- Dosimetry Check (Math Resolutions Inc.)
- AirQA (HFR, Switzerland)
 - Pisaturo et.al. PMB (60) 1625-1639 2015
- Delivery Analysis (Accuray Inc.)

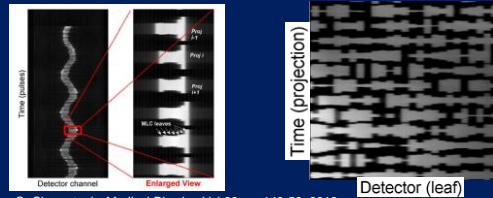
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Detector data analysis II

For 300Hz sampled detector data (rawData):

- Detect leaf open/close from the abrupt signal change
- Not affected by attenuation

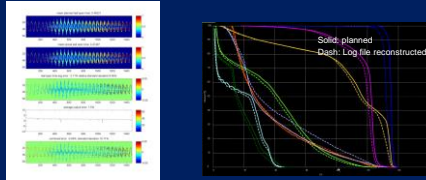


Q. Chen et. al., *Medical Physics*, Vol 39, pp 143-52, 2012.
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Implementations

- MCLogQA (University of Virginia)
 - L. Handsfield, et. al., *Medical Physics*, Vol 41(10):101703, 2014



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SAMS Question

Which of the following information is not included in the Tomo Log file?

- Gantry angle
- Couch translation
- MLC position
- Jaw position
- Dose rate

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Which of the following information is not included in the Tomo Log file?

- Answer: C. MLC position

– Q. Chen et. al., "Real Time MLC Verification Using Exit Detector Data", *Medical Physics*, Vol 39, pp 143-52, 2012.

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What does Log File QA provide

- Faster and simpler pre-treatment QA
- Detailed information on every fraction
- Trending of machine performance
- Diagnostic of patient QA discrepancies

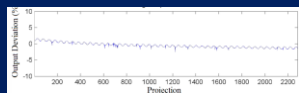
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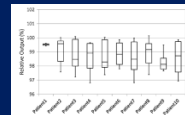


Output fluctuations

Intra-fraction:



Inter-fraction:



L. Handsfield, et al., *Medical Physics*, Vol 41(10):101703, 2014

Z. MOUTRIE et al., *JACMP*, vol 16, 2015

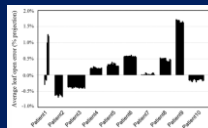
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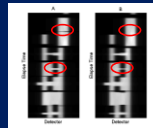


MLC performance

Plan dependent error

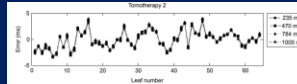


Interfraction variation



L. Handsfield, et al., *Medical Physics*, Vol 41(10):101703, 2014

Bias of each leaf



Seviliano, et al., *Medical Physics*, Vol 39(11):6972-80, 2012

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Review of each fraction

Treatment Summary Dashboard

Chapter 2. Treatment Summary

Translation, Rotation, Similarity, Output Mean, Output Variation, Gamma

Table 2.1: Thresholds

Parameter	Value	Comment
Translation	0.1	mm
Rotation	0.1	deg
Similarity	0.9	
Output Mean	0.99	%
Output Variation	0.1	%
Gamma	2	mm

Table 2.2: Treatment Summary

Serial	Machine	Leaf	Output	Translation	Rotation	Similarity	Output Mean	Output Variation	Gamma	Pass/Fail	Comments
20130001	10100	0001	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130002	10100	0002	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130003	10100	0003	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130004	10100	0004	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130005	10100	0005	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130006	10100	0006	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130007	10100	0007	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130008	10100	0008	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130009	10100	0009	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130010	10100	0010	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130011	10100	0011	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130012	10100	0012	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130013	10100	0013	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130014	10100	0014	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130015	10100	0015	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130016	10100	0016	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130017	10100	0017	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130018	10100	0018	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130019	10100	0019	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130020	10100	0020	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130021	10100	0021	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130022	10100	0022	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130023	10100	0023	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130024	10100	0024	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130025	10100	0025	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130026	10100	0026	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130027	10100	0027	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130028	10100	0028	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130029	10100	0029	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130030	10100	0030	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130031	10100	0031	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130032	10100	0032	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130033	10100	0033	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130034	10100	0034	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130035	10100	0035	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130036	10100	0036	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130037	10100	0037	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130038	10100	0038	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130039	10100	0039	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130040	10100	0040	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130041	10100	0041	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130042	10100	0042	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130043	10100	0043	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130044	10100	0044	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130045	10100	0045	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130046	10100	0046	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130047	10100	0047	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130048	10100	0048	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130049	10100	0049	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	
20130050	10100	0050	0.99	0.05	0.05	0.95	0.99	0.05	2	Pass	

Tomogamma
21st Century
Oncology

Courtesy of
Weiguo Lu

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Dose Reconstruction

Evaluate the impact of errors to the deliver dose

Planned Fluence Sinogram

3D Dose Calculation using Measured MLC Leaf-Open Times

MLC Fluence Wash



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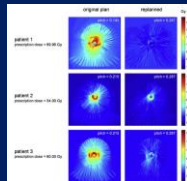
Improve patient QA passing rate

Int. J. Radiation Oncology Biol. Phys., Vol. 74, No. 4, pp. 1290-1297, 2009
TREATMENT PLANNING TO IMPROVE DELIVERY ACCURACY AND PATIENT THROUGHPUT IN HELICAL TOMOTHERAPY

DAVID C. WESTERLY, M.Sc.,^{1*} EMILIE SORSSON, M.Sc.,¹ QUAN CHEN, Ph.D.,¹ KATHERINE WOCH, M.Sc.,¹ LEAH SCHUBERT, M.Sc.,² GUSTAVO OLIVEIRA, Ph.D.,^{1,2} AND THOMAS R. MACKIE, Ph.D.^{1,2}

¹Departments of Medical Physics and ²Human Oncology, University of Wisconsin, School of Medicine and Public Health, Madison, WI

Log file analysis revealed the root cause for the DQA failing. A re-planning strategy was proposed.



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SAMS Question

Without the Dose Control Servo, how much inter-fraction output variation for Tomotherapy Linac is expected

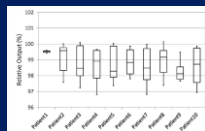
- A. 0.5%
- B. 1.0%
- C. 2.0%
- D. 3.0%
- E. >3.0%

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Without the Dose Control Servo, how much intrafraction output variation for TomoTherapy Linac is expected

- Answer C: ~2%



L. Handsfield, et. al., "Phantom-less patient specific TomoTherapy QA", *Medical Physics*, Vol 41(10):101703, 2014

Z. MOUTRIE et. al. First experiences in using a dose control system on a TomoTherapy Hi-Art II. *JACMP*, vol 16, 2015

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Log file Limitations

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 16, NUMBER 1, 2015

Parallel/Opposed: IMRT QA using treatment log files is superior to conventional measurement-based method

Nathan Childress,¹ Quan Chen,² Yi Hong²

MedStar Medical Systems,¹ Houston, TX; Department of Radiation Oncology,² University of Virginia, Charlottesville, VA; Department of Radiation Oncology,³ Ohio State University Wexner Medical Center, Columbus, OH, USA

- Limited information about how it is measured.
 - Accuracy
 - Agnew et al. PMB 59(9) 2014
 - Independence
 - Monitor chamber reading is used by DCS
 - Completeness
 - Beam profile, energy not directly measured

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Summary

- Continuing development of TomoTherapy Log file based QA tool
- Log file based approach provides rich information on the treatment delivery

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