JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING EASTERN TIME [GMT-4]

Gross patient error detection via cine transmission dosimetry

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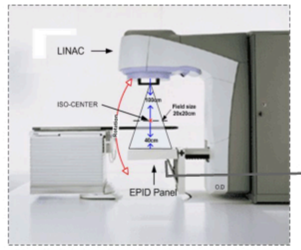
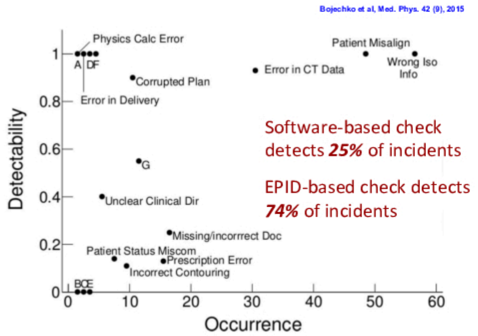
INTRODUCTION

- Radiation therapy requires robust verification in order to prevent errors.
- EPID dosimetry can be used as an effective quality control verification.



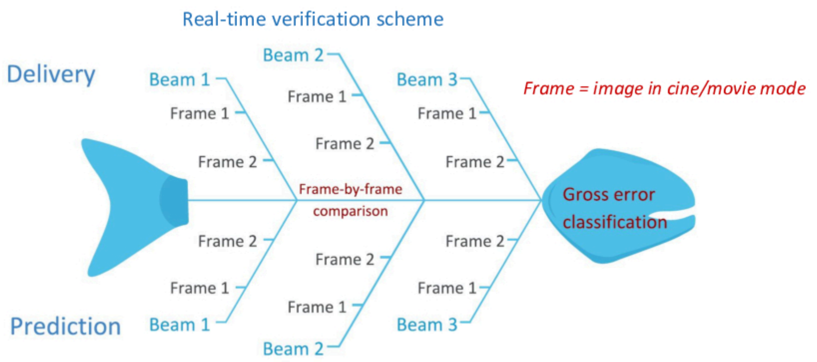


AIM

To quantify the effectiveness of EPID-based cine transmission dosimetry to detect gross patient anatomic errors in real time:

- ***Gross patient miss-alignments*** (patient shifting and rotation)
- ***Incorrect patient*** (distinguishing gross patient miss-alignments or wrong-patient from in-tolerance inherent patient variations)

METHOD



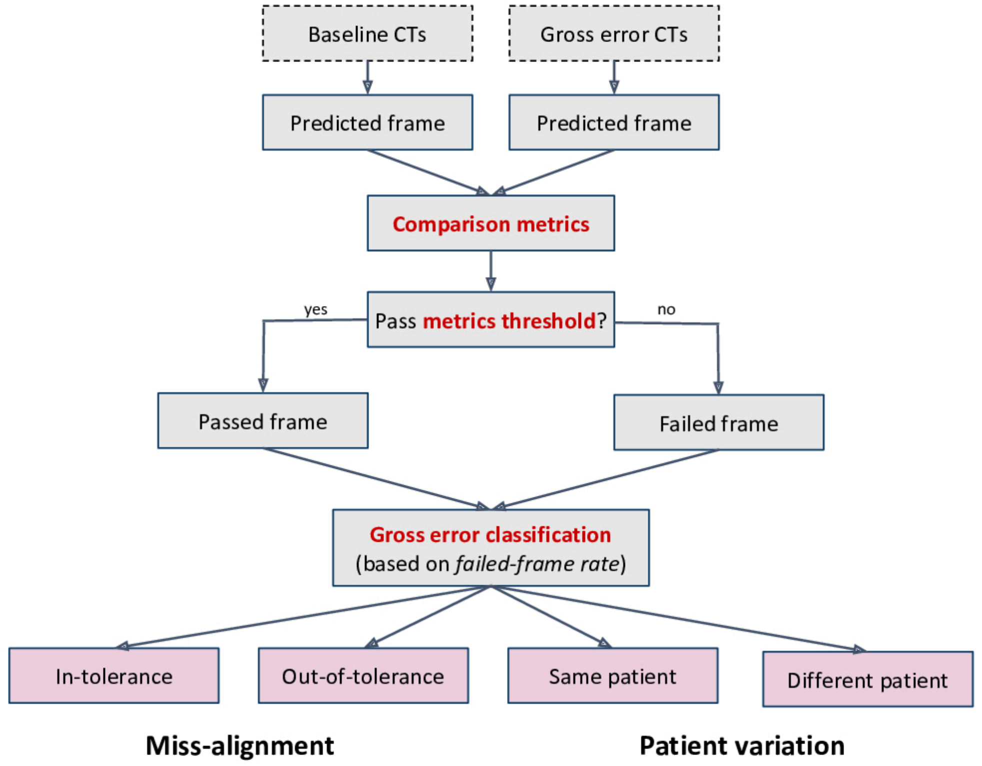
Step 1: *Predicting EPID image frames*

- ***Patient data:*** 10 H&N and 19 prostate CTs
- ***Prediction tool:*** in-house software (**intrEPID**)
- ***EPID cine dosimetry:*** 6MV VMAT delivery with ~100 msec per frame

Step 2: *Per-frame analysis*

- ***Patient miss-alignment:*** *10 H&N and 19 prostate cases*
  - ***Baseline:*** 1-3 mm shifts and 1-3° rotations (*in-tolerance*)
  - ***Gross error:*** 10-20 mm shifts and 10-15° rotations (*out-of-tolerance*)
- ***Incorrect patient:*** *19 prostate cases*
  - ***Baseline:*** same patient with 9-12 different treatment day CTs
  - ***Gross error:*** different patient CTs

GROSS PATIENT ERROR DETECTION

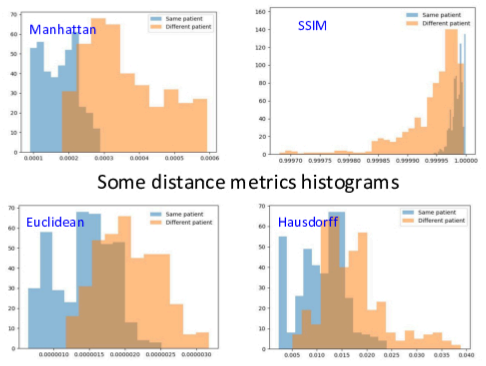


Comparison metrics

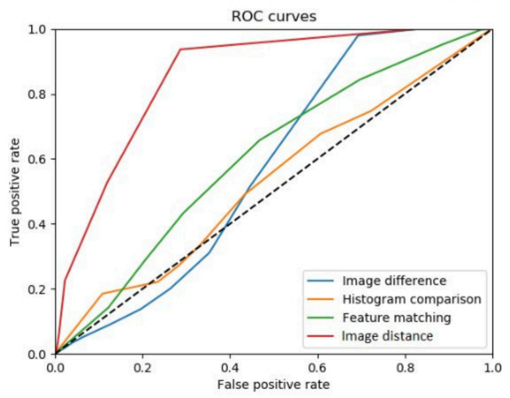
Frame-by-frame comparison metrics:

- ***Image difference:*** maximum difference between two images larger than a threshold
- ***Histogram difference:*** difference between two image histograms
- ***Feature matching:*** difference between two sets of image features (*peaks*)
- ***Image distance:*** sum of absolute image difference (*Manhattan*)

Comparison of different image distance metrics for a single test case (prostate). Among them, Manhattan distance give the best discriminating power.

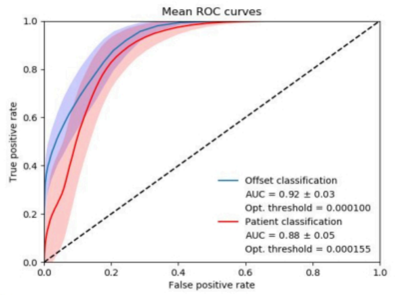


Comparison of ROC curves (patient variation classification) from different frame- by-frame metrics. The image distance (Manhattan) gives the best ROC curves.



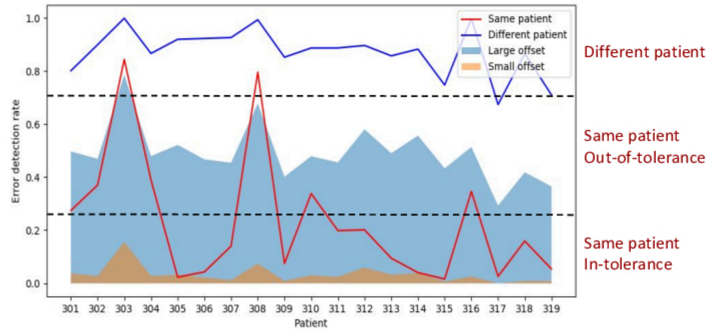
Metrics threshold

Mean ROC curves from 19 prostate patient datasets. The red line shows ROC curve for the miss-alignment classification, while the blue line shows ROC curve for the incorrect patient one. The gross error detection threshold (opt. threshold) is determined as the point which has highest TPR/FPR ratio.



Gross error classification

Error detection rates (failed-frame rate) from 19 prostate patients. The rate thresholds are chosen in order to distinguish different types of gross patient errors.



DISCUSSION AND CONCLUSION

The objective of this study is to determine if gross patient miss-alignments or even the incorrect patient can be distinguished from in tolerance patient variations via analysis of the fluence which passes through the beam aperture.

If successful, this study could prevent rare, but gross and dosimetrically consequential errors which might otherwise be missed in radiation therapy.

Furthermore, once gross errors are detectable, then the possibility of detecting smaller non-gross errors becomes possible.

The method for gross patient error detection was based on the cine transmission dosimetry (~10 frames/sec) of EPID. Different frame-by-frame comparison methods were compared, ROC curves show the best performance belong to ***image distance metrics***.

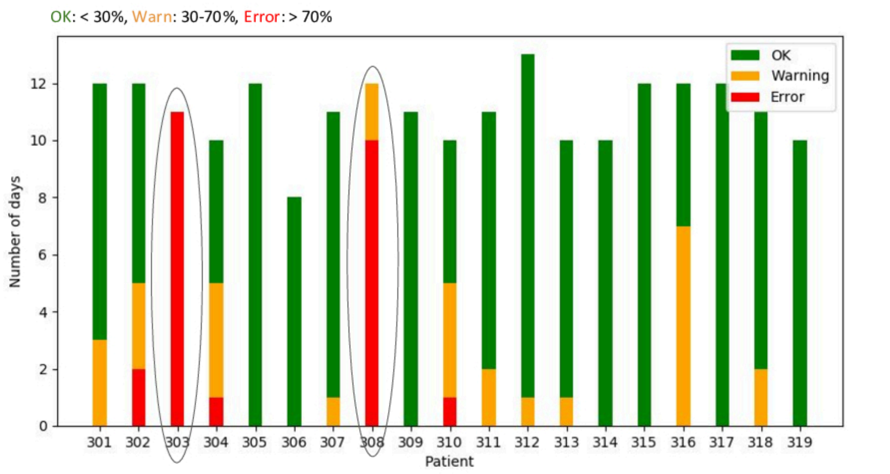
The results in this study show that the error detection method was able to distinguish gross patient miss-alignment from in-tolerance levels for both 10 H&N and 19 prostate datasets. In addition, for the prostate datasets, the methods utilized were also able to distinguish the incorrect patient errors from the baseline.

With the EPID cine mode, the gross error detection was validated using 19 prostate cases, each case has CTs for 9-12 treatment days. There were two patients may have had gross changed (e.g. in rectal gas) from the 1st day. For the rest, our method detected gross errors of 4/178 days.

In conclusion, in-field gross error detection was possible for miss-alignments and incorrect patient.

*Gross patient error detection with 19 prostate patients. Days without any error detection (frame detection rate < 30%) are labeled in **green**; days with high risk of error detection (frame detection rate between 30% and 70%) are labeled in **orange**; and days with error detection (frame detection rate > 70%) are labeled in **red**.*

Frame detection rate was calculated by comparing frames from the first treatment day with the ones from the following treatment days.



ACKNOWLEDGEMENT

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