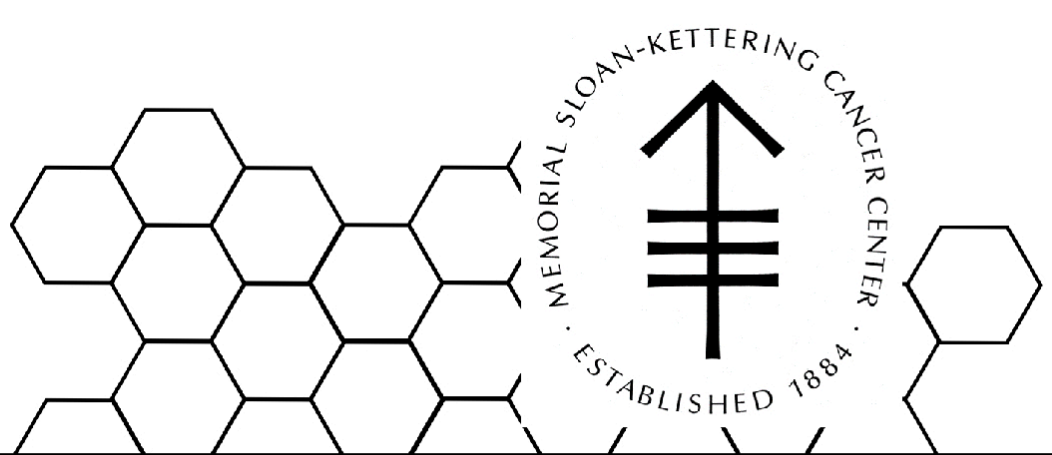# Checking sanity and integrity of treatment plans in MR-linac based adaptive radiotherapy

Pengpeng Zhang, Jianping Xiong, Anyi Li, James Mechalakos, Neelam Tyagi
Medical Physics Department, Memorial Sloan Kettering Cancer Center, NY USA

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

INTRODUCTION

MR-linac enables online adaptations to accommodate daily setup variations, target/organ shifts and deformations.[1] In the clinical workflow of daily treatment using a Unity MR-linac (Elekta, Sweden), the online verification of the adaptive plan of the day presents challenges because a dosimetric verification is not feasible in a short time when the patient is on the table. Instead of directly verifying the dosimetric accuracy of the adaptive plan, we followed the alternative framework proposed by Chen et al[2] to comprehensively compare the treatment plan of the day against the reference plan which is generated and QAed offline, and ensure that the adaptive plan retains significant similarity therefore inheriting the comfortable level of accuracy in the reference plan. In addition we perform verifications of data transfer integrity between Monaco (planning system) and Mosaiq (record and verify system). Both independent sanity and integrity checks are critical to rule out gross errors and install the confidence in the clinical team.

AIM

To developed a computerized independent program (called CSITP), that checks the sanity of the adaptive plan, and ensures the integrity of data transfer.

METHOD

we use CSITP to calculate the deviations comparing the adaptive plan of the day (P_{AD}) to the original reference plan at simulation (P_{OR}) or the treatment plan of the previous day (P_{PD}) on a wide spectrum of dosimetric driven parameters, including beam angle, number of segments, segment area, MU weighted segmentation area, center of mass of the fluence, and MU. Thresholds of mismatch that trigger alerts are determined by carefully analyzing intentionally introduced variations as well as actual patients' plans for the clinical scenarios of both "adapt to position" and "adapt to shape". After P_{AD} is approved in the treatment planning system (Monaco), it is pushed to the treatment delivery and management system (Mosaiq). Since Monaco and Mosaiq host two separate databases, CSITP automatically queries the two databases, and verifies that plans in the two systems are identical and free from possible corruption errors in data transfer. Checking activities are logged for future chart round review and analysis. The program checking sanity and integrity is written in c++/c# on the .net framework. It is based on an earlier version developed for checking the integrity of Eclipse/ARIA plans. Its design flowchart is illustrated in Figure 1. The user interphase design and an example of sanity check is shown in Figure 2.
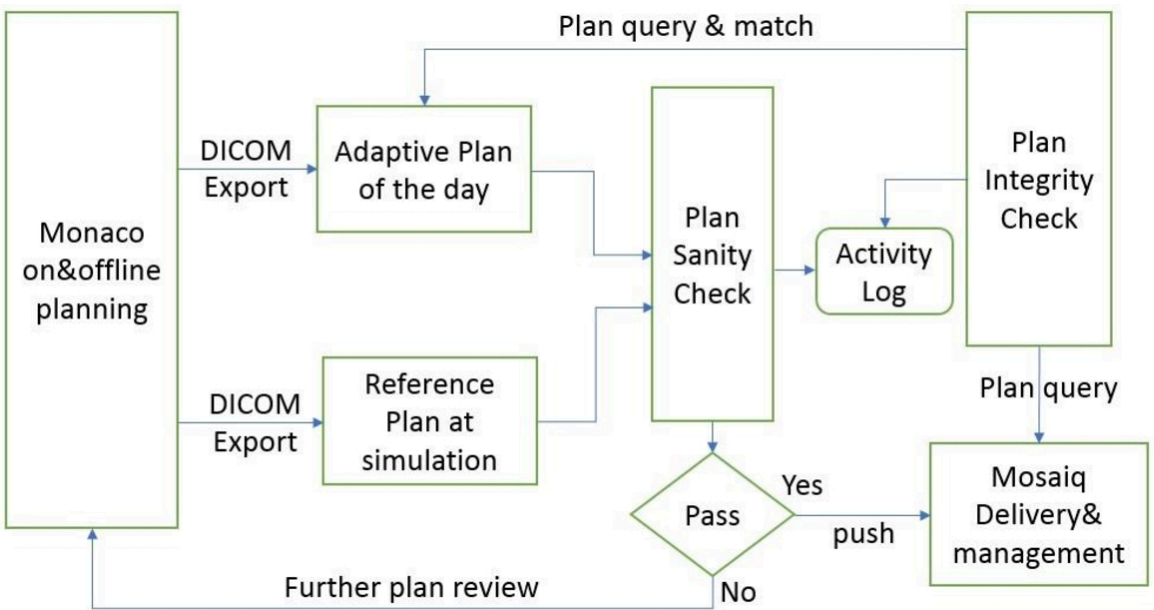

Figure 1. Flowchart of the automated program checking the sanity and integrity of the treatment plan.
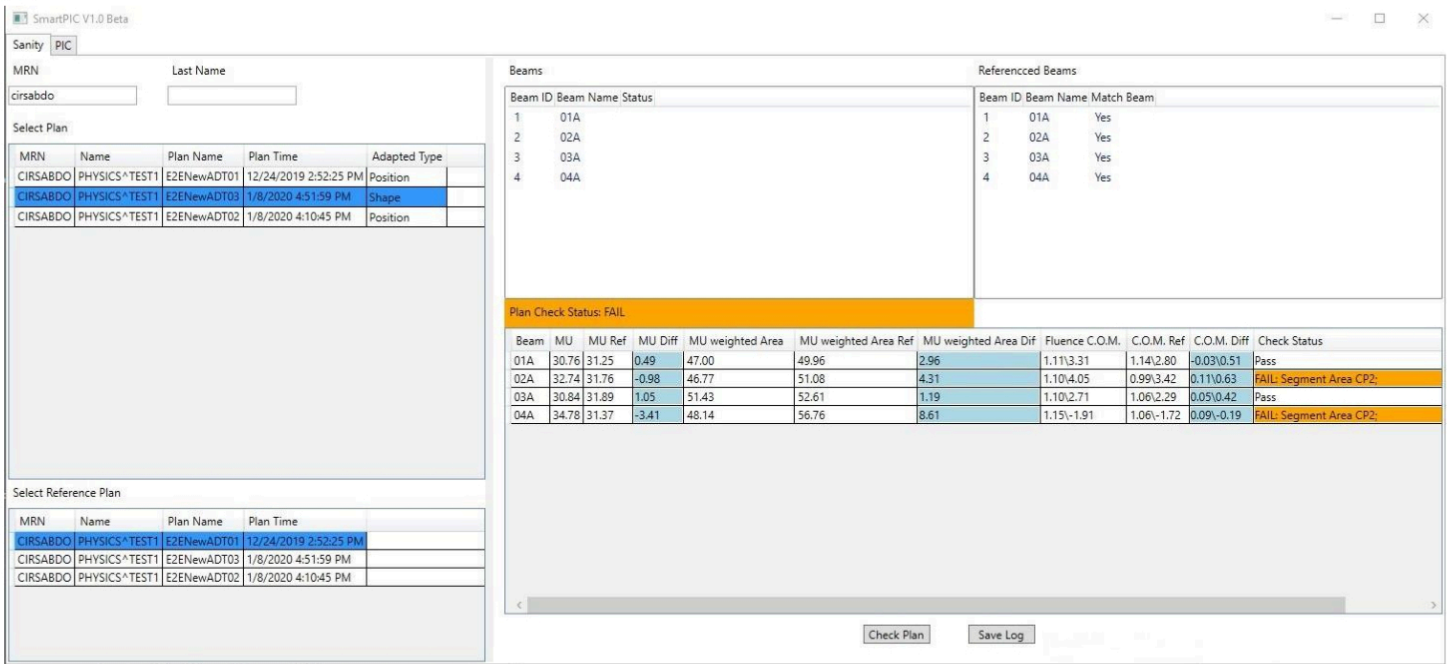

Figure 2. An example of sanity check under the scenario of "adapt to position". The adaptive plan doesn't pass the sanity check because an intentional shift of more than 1cm was introduced in setup.

RESULTS

1. The plan of the day is more similar to the plan of the previous day, compared to the plan at simulation. By default, we use the plan of the previous day as reference plan in sanity check.
2. The thresholds for alerts are set to 5%/5mm and 20%/2cm for the clinical scenario of "adapt to position" (small changes) and "adapt to shape" (large changes), respectively. CSITP can catch intentional errors introduced in testing.
3. MU weighted segment area seems to be a robust measure to signal significant deviations of the plan of the day compared to the reference plan.
4. The execution of CSITP only takes a few seconds, imposing no burden on the entire clinical workflow.

CONCLUSIONS

CSITP can perform independent check of the sanity and integrity of the adaptive plan, and provide raw data for analyzing and improving workflow and quality assurance. Proper alerting criteria need further investigations with more accumulated patient data.

REFERENCES

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2. Chen X, Ahunbay E, Paulson ES, Chen G, Li XA. A Daily End-To-End Quality Assurance Workflow for MR-guided Online Adaptive Radiation Therapy on MR-Linac. J Appl Clin Med Phys. 2020 Jan;21(1):205-212.

CONTACT INFORMATION

Pengpeng Zhang: Zhangp@mskcc.org