Advanced Camera Optimization

Clinical Research Summary

Vicky Howard, M.S., MBA, DABR

Clinical Physicist, Vision RT

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Advanced Camera Optimization White Paper – Vision RT 2018[1]

Vision RT, the market leader in radiation therapy surface imaging systems, is committed to continually pushing the envelope of SGRT innovation through its focused and dedicated research and development initiatives. With the goal of further enhancing the accuracy and stability of AlignRT over the growing spectrum of clinical applications, Vision RT has developed Advanced Camera Optimization (ACO) and the optical setup tool (OST), an innovative optical setup and calibration technique performed by our dedicated SGRT service engineers. The ACO process enables optimal volumetric camera pod calibration to achieve high levels of accuracy over the full array of treatment scenarios, thus addressing the three challenges inherent to any SGRT system: i) consistent accuracy across a range of isocentre locations, ii) 6DOF real-time-delta (RTD) stability despite single camera pod occlusion, and iii) maintaining accuracy for all couch rotations. To demonstrate the robust performance of AlignRT 6DOF surface tracking with ACO, the system accuracy and stability were assessed via a series of phantom studies.

- End-to-end tests were performed using 1 mm slice thickness CT scans of both a MAX-HD (IMT Inc., Troy NY) anthropomorphic cranial phantom, and the Vision RT MV Isocenter Calibration Cube rotated 45 degrees from the calibration position.
- Clinically relevant plans were created to provide challenging configurations for surface setup and tracking; large couch rotations, deep isocenters (up to 18cm below setup surface), clinically relevant regions of interest, and camera pod occlusions.
- Study results showed changes in RTD values due to varying surface location or pod occlusions to be on the order of 0.1 mm in phantoms.
- Additionally, AlignRT with ACO was shown to provide sub-0.4 mm tracking accuracy for the full range of couch rotations, and sub 0.2mm accuracy for coplanar configurations.

These results show the clinical viability of AlignRT with ACO as a precise and accurate setup and monitoring tool over a wide spectrum of treatment configurations. The enhanced performance of AlignRT with ACO has been validated in several clinical research studies which are summarized below.

Direct Comparison Between Surface Imaging and Orthogonal Radiographic Imaging For SRS Localization In Phantom – Wiant et al. 2019[2]

This work systematically compared the AlignRT surface imaging system (Vision RT Inc, London, UK) with ACO versus the ExacTrac room mounted x-ray localization system (Brainlab AB AG, Feldkirchen, Germany) in an anthropomorphic head phantom to evaluate positional accuracy as a function of couch angle, head tilt, and isocentre position with respect to on-board imaging shifts on a Varian Truebeam (TB). Below is a summary of the key findings:

- Winston-Lutz measurements showed up to 0.9 mm table displacement due to inherent machine couch walkout at -90 degree couch angle which was in agreement with TB on-board imaging magnitudes up to 1.1mm at -90 degrees. The TB on-board imaging readings were considered to be reasonable ground truth for AlignRT and ExacTrac comparisons.

[1] Waghorn B. Advanced Camera Optimization. *Vision RT White Paper, 2018*. 1016-0238
[2] Wiant D, et al. Direct comparison between surface imaging and orthogonal radiographic imaging for srs localization in phantom. *J Appl Clin Med Phys* 2019;20 (1):137-144. https://visionrt.egnyte.com/dl/ln00CXI2fd

- AlignRT with ACO calibration showed comparable or better stability than ExacTrac. The mean AlignRT SD was 0.06 mm, which included measurements with partial camera blockage.
- Both AlignRT and ExacTrac displacement vector magnitudes showed comparable positional accuracy at all couch angles.
- Head tilt is an important consideration in patient setup when using AlignRT. With ACO, AlignRT continued to produce submillimeter accuracy at the largest head tilt.

Based on these phantom measurements AlignRT with ACO calibration is suitable for non-coplanar intrafraction SRS localization and it offers real time monitoring with accuracy comparable to ExacTrac.

Optical Surface Guidance For Submillimeter Monitoring Of Patient Position During Frameless Stereotactic Radiotherapy – Covington et al. 2019[3]

This work performed at University of Alabama, Birmingham, evaluated the effect of the Advanced Camera Optimization (ACO) volumetric calibration procedure and an improved isocenter calibration workflow (CIB)[4] on the accuracy of non-coplanar monitoring of intrafraction motion during frameless FFF-VMAT stereotactic radiotherapy (SRT) on an Edge linear accelerator using OSMS (c.f. AlignRT). Real-time delta (RTD) offsets relative to the table zero reference position obtained following image-guided setup were recorded at i) each table position before beam-on, ii) during gantry motion when a camera pod was blocked, and iii) at the end of treatment at the reference position. Patient data was collected prior to ACO and CIB, after ACO but prior to CIB being performed, and after CIB. Below is a summary of the key research findings:

- Prior to ACO, the median translational magnitude for non-zero table positions before beam-on had a median of 0.79 mm and was found to increase with increasing distance from isocentre to the anterior patient surface.
- After ACO, the median translational magnitude was 0.74 mm, however the dependence on isocentre location was eliminated.
- After CIB, the median magnitude for non-zero table positions was reduced to 0.57 mm.
- The presented data includes couch walkout, which is known to be on the order of approximately 0.3mm.

Overall, OSMS with ACO was determined to be capable of recording submillimetre deviations from the patient's initial reference surface from beginning to end of treatment and is a valid setup and monitoring technique for SRS treatments. At the time of publication UAB had treated over 800 stereotactic cranial fractions using OSMS guidance, including HyperArc and functional cases. They continue to use OSMS with ACO as the standard of care for cranial stereotactic radiosurgery.

[3] Covington EL, et al. Optical surface guidance for submillimeter monitoring of patient position during frameless stereotactic radiotherapy. *Journal of Applied Clinical Medical Physics* 2019;20 (6):91-98. https://visionrt.egnyte.com/dl/32Ohge1EzZ

[4] CIB2017SN0005 v1.0, Form 059 Issue No. 1.2, Updates to MV Isocenter Calibration Workflow. file://egnytedrive/visionrt/Shared/Clinical%20Operations/Physics%20Documents/CIB_MVIsoCalib_CIB2017SN0005v1.0.pdf.

SGRT Community Presentation – Innovation-Driven Precision: Where Are We Today And Where We Go From Here – Jursinic 2019[5]

- The AlignRT optical isocenter is calibrated to be coincident with the MV radiation isocenter at zero couch position, however the MV radiation isocenter is dependent on the center of rotation of the collimator, gantry and couch (couch walkout).
- The Lutz test is a radiographic imaging test that measures the position of the MV radiation isocenter as a function of couch rotations, and can be used concurrently with AlignRT surface tracking.
- The Lutz couch walkout measurements were compared to AlignRT. Results showed that AlignRT with ACO can track couch walkout within 0.2 mm Sup-Inf and 0.3 mm Lt-Rt, a two-fold improvement from 0.6 mm AlignRT accuracy without ACO.

AlignRT with ACO achieves both enhanced linear and angular accuracy enabling open faced mask use for Trigeminal Neuralgia treatments and single isocenter, multiple met treatments with smaller margins. Additionally, fewer false positive deltas in patient motion leads to increased time savings and lower imaging dose due to fewer re-imaging CBCTs.

[5] Paul Jursinic Presentation at AAPM SGRT Community Event, San Antonio, 2019 https://visionrt.egnyte.com/dl/KfbWHes3Ue