OC-0191 MLC-tracking latencies on Elekta Unity

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Purpose or Objective

Compared to previous guidance techniques, on-line MRI-guidance promises imaging during radiation and superior soft-tissue contrast. MR-images can be acquired in physiologically relevant frequencies and with clinically acceptable latencies [1]. In this work, we present the current status and latency figures of MRI-guided MLC-tracking on the Elekta Unity (Elekta AB, Sweden), which was previously discussed in [2].
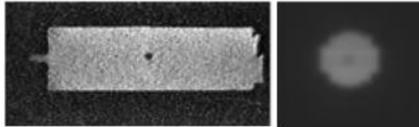
Material and Methods

Illustration 1: Phantom in MRI (left) and portal imager (right)

All experiments were performed on a clinical Elekta Unity with modified control software to enable MLC-tracking. The machine integrates a high-field (1.5T) MRI and a 7 MV linac. For the experiments, a circular beam was shaped using the on-board MLC (80 leaf pairs running in IEC1217-y direction). A cylindrical phantom was set in sinusoidal motion using a QUASAR MRI4D motion stage (Modus QA, Canada). The phantom was filled with agar to be detectable by MRI and a ZrO_2 ball bearing for EPID-contrast (Illustration 1). To determine latency between real displacement and the MLC's reaction, EPID images (30Hz frame-rate) captured the position of the moving ball bearing and the projection position of the circular beam tracking the position of the phantom. Both positions were fit to a sinusoidal model which was used to extract the phase shift between the two curves. Real-time position variables for tracking were sourced from 1) the motion stage with real-time position feedback (<1ms latency, 25Hz, STAGE) and 2) MRI images sampled with 4Hz (MRI4Hz) and 8Hz (MRI8Hz), respectively. The MRI images were acquired using T_1-weighted FFE -sequences (TR/TE=2.6/1.44ms,α=6°) and streamed via a proprietary TCP-based interface. The current image position was extracted via detection of the edge of the phantom in the direction of motion.
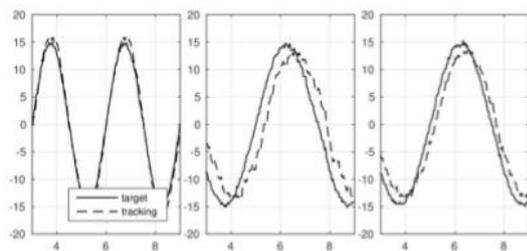
Results

Illustration 2: Tracking results for MLCONLY (left), MRI4Hz (center) and MRI8Hz (right)

Illustration 2 shows the tracking results. Naturally, because of the negligible position sensor latency, STAGE matches almost perfectly with the target position. The apparent latency was quantified at 20.67 ms. The tracked position overshoots. This is likely due to the control mode of the control system.

For the MRI-guided tracking, the impact of the longer latency for lower MRI-frequencies become apparent. MRI4Hz yields an apparent latency of 288 ms, while MRI8Hz has a lower latency of only 205 ms. Both MRI-guided

experiments show a loss of amplitude fidelity as the images cannot resolve the peaks of the excursion but can only interpolate between samples.

Conclusion

In this work we demonstrate stable tracking responses for the clinical MRI-linac system. Using the independent EPID imager, independent measurements of the tracking performance could be collected. Previously observed oscillatory behavior [2] could be stabilized using an improved version of the control system.

[1] Borman PTS et al. (2018) Characterization of imaging latency for real-time MRI-guided radiotherapy, Phys. Med. Biol. 63, 155023
[2] Glitzner M. et al. (2018) First MLC-tracking on the 1.5T MR-linac system, Radiotherapy and Oncology 127 , S101 - S102

OC-0192 Prerequisites for using "rapid learning" to optimise technical radiotherapy

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Purpose or Objective

Technical improvements in radiotherapy such as image-guidance are often adopted with enthusiasm without trial or long-term evaluation due to their presumed benefit. "Rapid learning" describes a continuous improvement methodology to monitor the impact of changes and iteratively optimise clinical practice. We previously showed that the direction of residual set-up errors (i.e. shifting the high-dose region *towards* the heart) was *not* correlated with clinical parameters yet strongly correlated with poorer survival in lung cancer patients: this makes shift data vs survival an ideal model system for rapid learning. In this work, we demonstrate that the correlation between residual set-up errors and survival is removed after the application of a stricter IGRT protocol. Since rapid learning must be *rapid*, we also evaluate the minimal number of patients and minimal follow-up to detect this change.

Material and Methods

Locally advanced NSCLC patients treated with curative intent in our institution since 2008 were included in the analysis. Patients were treated with IGRT using bony anatomy registration on CBCT (Elekta XVI version 4.2 or 5.0).

Patients were divided into:
1. i) a "before" cohort (pre-November 2016, 780 patients), positioned using an extended non-action level protocol with a 5mm tolerance level,
2. ii) an "after" cohort (post-November 2016, 225 patients), positioned with daily CBCTs and a 2mm tolerance level.

We performed a sensitivity analysis using the "before" cohort to determine the minimal size of the subset of patients required to reliably observe the survival effect. Next, this number of patients was selected from both the "before" and "after" cohorts around the time of implementation of the change i.e. the last and first patients treated with both IGRT protocols, and the analysis repeated.

Results

Sensitivity analysis showed that 180 patients (~4 months accrual in our institution), followed up for 1 year, were sufficient to observe the survival effect in the "before" cohort with a power of 0.9 (Fig. 1). The survival discrepancy observed in the "before" cohort was not detected in "after" patients (Fig. 2) – i.e. changing IGRT

protocol significantly reduced the hazard of death to less than that in the "before" cohort.

This shows that a rapid learning approach can provide evidence of the impact of a change to clinical practice in a much shorter timeframe (<1.5 year) than that of a clinical trial.

Conclusion

This retrospective analysis demonstrates that continuous monitoring of patient outcomes, or rapid learning, can systematically provide evidence of the impact of even small changes in radiotherapy practice, and highlight where improvements can be made. Furthermore, as it necessarily takes place within a continuously monitored environment, it can make implementing such changes safer as adverse effects will be quickly detected. Rapid learning is complementary to clinical trials, provided that appropriate model system is used.

Proffered Papers: RTT 2: A patient centered approach to follow up

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OC-0193 Mobile application for daily patient scheduling during radiotherapy treatment course
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Purpose or Objective
Currently most of the radiotherapy (RT) treatments are delivered with multiple treatment fractions in consecutive days. The RT patients are scheduled for a certain treatment machine and a daily pattern is given as a sequence of treatment days. Currently in most of radiotherapy departments in Finland the detailed timeslots are given to the patient once a week in advance on a paper. The purpose of this work was to determine whether a mobile phone application designed for patient scheduling can replace the previous workflow and simultaneously enhance the scheduling process overall and reduce the workload of the RT personnel.

Material and Methods
The testing of a mobile application (HMS, Healthcare Mobile Solutions) for patient scheduling was carried out at Kuopio University Hospital Radiotherapy department. During the three months testing phase (October 2017 – January 2018) 30 radiotherapy patients were involved in the test run. The initial and final patient daily scheduling was organized in Mosaiq (v2.62, Elekta AB, Stockholm, Sweden) patient verification system. The corresponding timeslots were given to the patients by the mobile application and also on the paper "time card", since we wanted to investigate the patient reported difference between the two methods. In the final phase of the planned treatment (range of the total treatment fractions 5-30), the feedback was collected from the participating patients with five-point scale questionnaire (1 = strongly disagree, 2= disagree, 3 = neither agree or disagree, 4=agree, 5 = strongly agree).

Results
The age distribution ranged between the participants in test run from 37-71 years. 75% of the patients were over 50 and 38% over 60 years old or older. 90,5% of the participants were using Android and 9,5% iPhone. The highest scores of the patient reported feedbacks were "the application was clear to use" (av 4.83, range 4-5), "the application worked well on my phone" (av 4.65, range 3-5) and "I would like to use such an application also on the future" (av 4.57, range 3-5). In addition, the overall feedback was that treatment related instructions given by the application were easily available (av 4.36, range 2-5)

and the patients would have chosen the application over the paper "time card" (av 4.32, range 3-5).

Conclusion
The mobile application was an effective tool for daily patient scheduling. The patient reported usability of the tested mobile application was high and none of the patients would have preferred the paper version of the time card, even though most of the patients were over 50 years old. In addition to the daily scheduling the application was used to give daily instructions and alerts for example for fasting and included treatment related instructions for the patients. This was the last step to convert our radiotherapy department into paper-less environment.
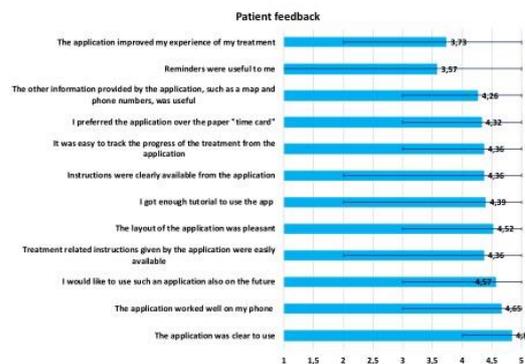
OC-0194 Continuous improvement by crossing patient satisfaction surveys, adverse events and complaints
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Purpose or Objective
Beyond the technological advances to improve Radiation Therapy (RT), the patient is a key player in security and improvement care processes. The patient's needs and expectations can be assessed through satisfaction surveys, adverse event declarations and records of complaints.

However by crossing individual complaints, satisfaction surveys in combination with adverse events received we could get valuable information. The objective is to identify common elements of work between these different sources to improve care and to obtain additional views of caregivers and patients about an event to be more complete and accurate in choosing improvement actions.

Material and Methods
A retrospective analysis of patient's complaints, surveys and adverse events was carried out in order to highlight common improvement items between these 3 sources of information. Adverse events bring together caregiver statements and unexpected events completed by patients. Complaints are sent to us by the hospital Mediation. The complaints, adverse events and areas for improvement defined in the satisfaction surveys were examined. This analysis was conducted between June 2017 and June 2018, we have cross-polled 249 improvement proposals from the surveys, with 7 complaints reporting and 13 patient completed adverse events.

Results
We first analyzed the 249 improvement proposals resulting from satisfaction surveys. We highlighted 5 criteria to improve: logistics and infrastructure (parking, waiting room), communication and information (brochure, information about treatment and on side effects), delays to treatment units (information delay, breakdowns), appointments (consultations) and the relationship with RT staff (doctors, nurses). We then compared them with complaints and patient related adverse events. Parking problem, treatment delays due to breakdowns as well as