Catalyst HD: Commissioning of an Optical Surface Monitoring System

Samuel Peet[†,‡], Candice Milewski[†,§], Steven Sylvander[†]

Background

We have recently commissioned a C-rad Catalyst HD (C-rad, Uppsala, Sweden) system at the Royal Brisbane and Women's Hospital. This installation is the first of its kind in Australia.

The Catalyst HD is an optical surface monitoring system designed to assist radiation therapists during patient setup, to monitor patient movement during treatment, and to hold the beam during respiratory-gated treatments.The Catalyst HD is comprised of three camera/projector units mounted to the ceiling of the treatment bunker. Each unit employs a high-power LED to project a striped pattern of violetlight (405 nm) onto the patient. The pattern becomes distorted when projected onto a curved surface, allowing for the digital reconstruction of the surface in real-time. These real-time images may be compared against reference images to assist the radiotherapy team during patient set-up. If local posture errors exist, two additional LEDs on each unit will project either green light (528 nm) or red light (624 nm) onto the patient surface indicating that corrections must be made. The system also detects gross errors that may be rectified with a couch translation, and automatically applies a couch shift. Scanning continues during treatment delivery, and tracks any movement of the patient isocentre. The beam may be held if the patient moves beyond a predefined tolerance. Respiration data captured by the companion C-rad Sentinel is also shared with the Catalyst HD system, allowing for deep-inspiration breath-hold techniques as well as free breathing beam gating.

Methods

We performed many tests suggested by the AAPM TG-147 [1] task group report for commissioning non-radiographic localisation systems: thermal drift and reproducibility were established with the included daily QA phantom; static localisation accuracy was benchmarked against CBCT by introducing known shifts to an anthropomorphic phantom (Fig 1); dynamic tracking of respiratory motion was investigated by affixing a patient shell to the driving arm of a water tank (Fig 2); and gated treatments were assessed with a moving phantom.

Further tests were performed to investigate the effect of skin tone and geometry on system performance. This was done by 3d printing a variety of geometric solids, painting them with selection of colors, and assessing their relative effect on localisation.

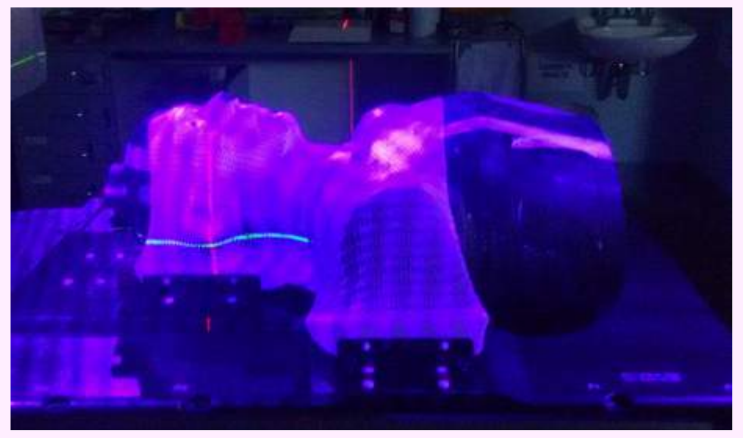


Fig 1: Anthropomorphic phantom bathed in violet light

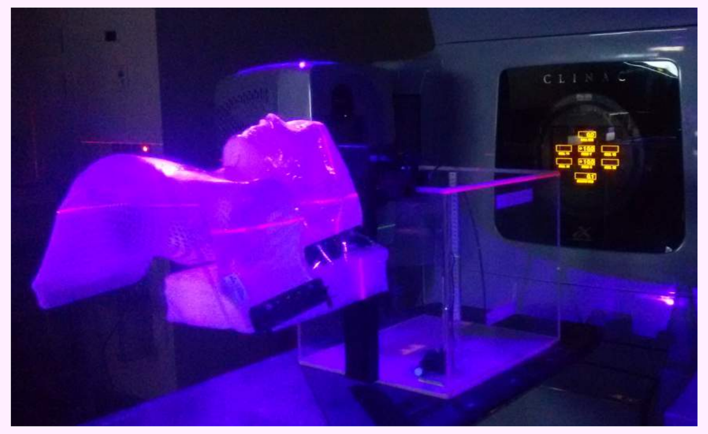
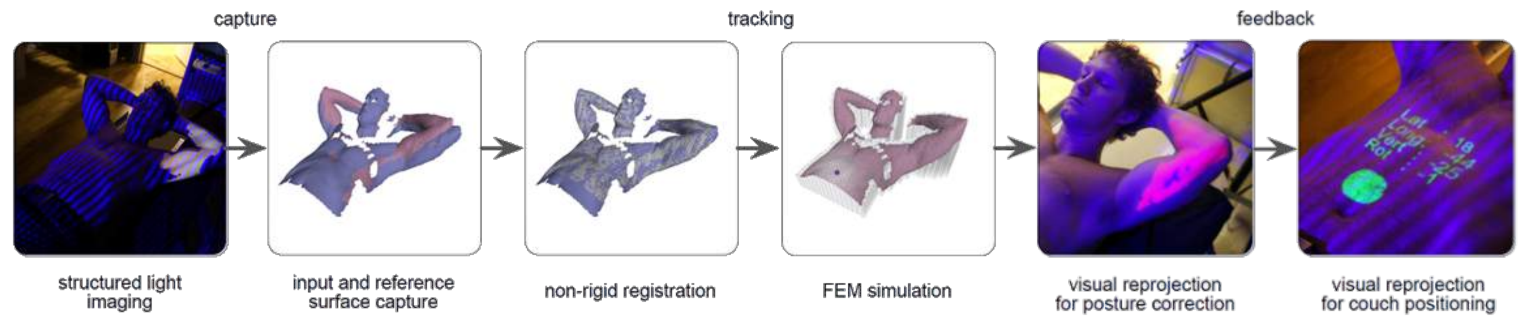
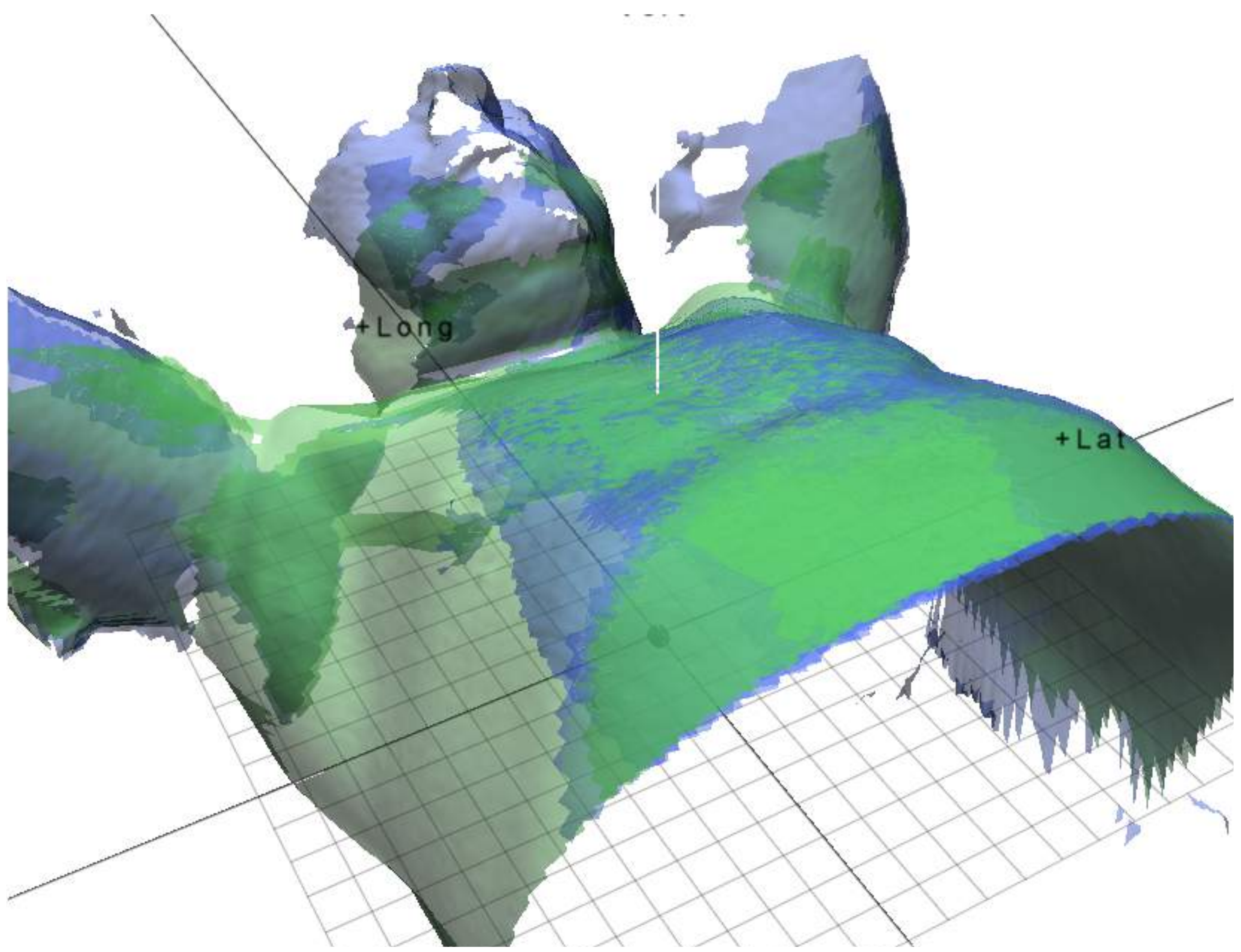


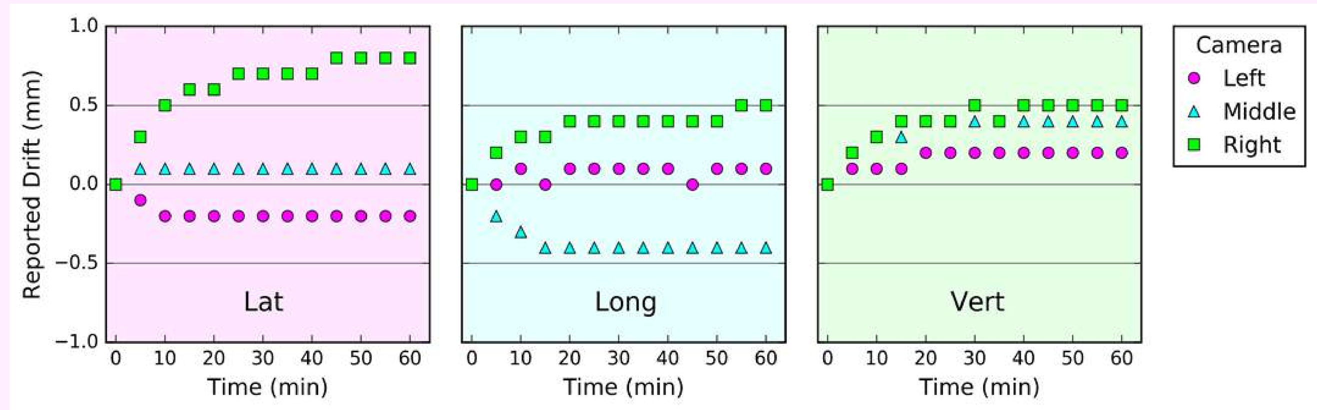
Fig 2: Shell affixed to driving arm of water tank





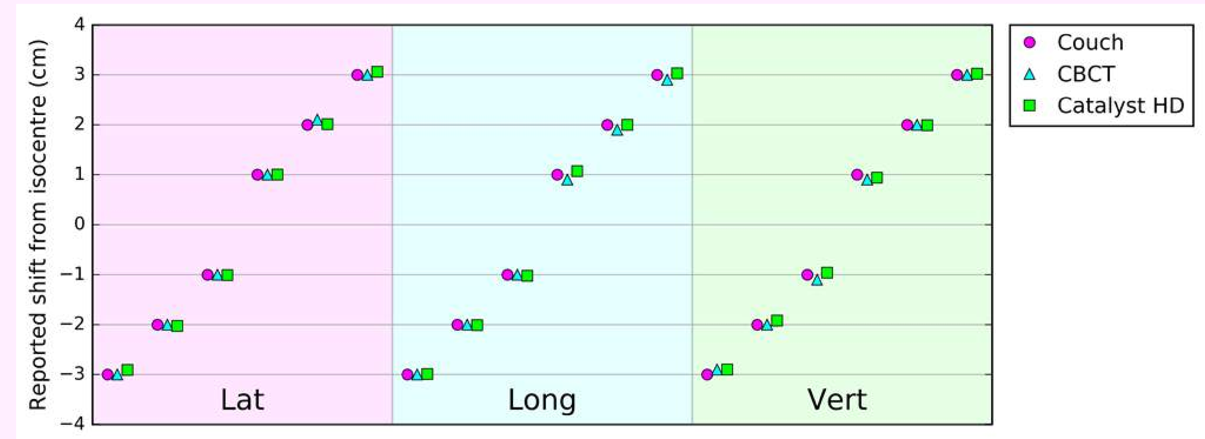
Results

Thermal Drift and Repeatability



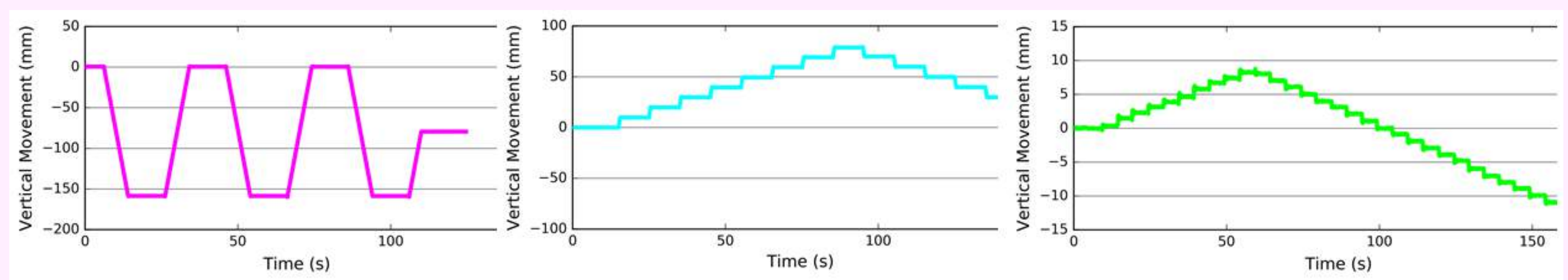
- A reliable warm up time was found to be 30 minutes, with a drift in displacement of 0.5 mm in this time.
- Beyond this, we found that the position of a static phantom was reproducible to approximately 0.2 mm.
- Having room lights on or off had no discernible effects on the results.

Static Localisation



- Known shifts were applied to the couch and the phantom was then imaged with both the Catalyst HD and CBCT.
- For the great majority of cases the disagreement between the Catalyst HD and CBCT was less than 1 mm.
- A more precise comparison could be gathered with a couch capable of reliable submillimetre shifts.

Dynamic Localisation



- The Catalyst HD respiratory trace was compared against the position of the water tank arm.
- The agreement was acceptable both spatially and temporally, with disagreements only at a submillimeter level.
- Point doses measured during heavily gated IMRT treatments agreed with non-gated deliveries within 0.5%

† Royal Brisbane and Women's Hospital, Butterfield Street, Herston, QLD 4029

‡ School of Chemistry, Physics and Mechanical Engineering, Queensland University of Technology, GPO Box 2434, Brisbane, QLD 4001

§ Univeristé Paris-Sud, Paris, France

[1] Willoughby T, Lehmann J, Bencomo J et al (2012) Quality assurance for non-radiographic radiotherapy localization and positioning systems: Report of Task Group 147. Med Phys, 39(4):1728-47