Beam's-eye-view tracking of prostate fiducial markers during VMAT treatments

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INTRODUCTION

- Monitoring fiducial marker locations using beam's-eye-view images is ideal as it eliminates the need for additional imaging equipment and provides target information in the most important frame of reference: the view of the treatment beam.
- Furthermore, the additional imaging dose from real-time fluoroscopic monitoring is high and can be unacceptable.[1]
- However, accurate tracking is challenging for VMAT treatments due to low contrast and MLC leaves occluding markers.
- Current common marker segmentation methods typically use template matching approaches.[2,3]

We present a novel beam's-eye-view fiducial marker monitoring system based on a convolutional neural network (CNN) classifier.

RESULTS

- The monitoring system had a mean error of -0.1±0.5mm and -0.1±0.6mm in the x- (lateral, anterior/posterior) and y- (superior/inferior) directions of the MV images, respectively (Fig. 3b).
- The [1st, 99th] percentiles of the error were [-1.6, 0.9] mm in the x-direction, and [-2.0, 1.3] mm in the y-direction.
- The classifier had a sensitivity of 98.31% and specificity of 99.87%. The area under the PRC plot (AUC) of the classifier was 0.99 (Fig. 3a).

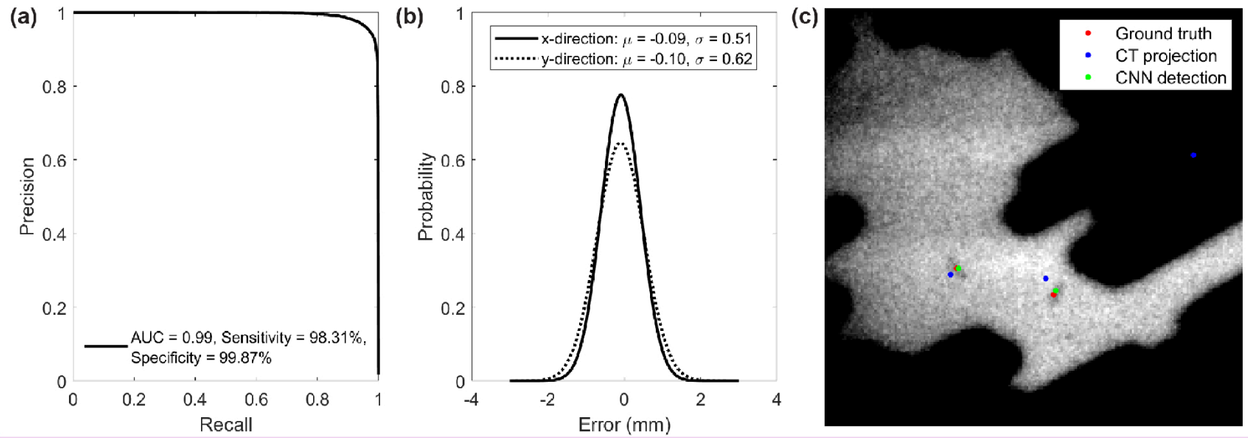

Figure 3. (a) *Precision-recall curve (PRC) plot of the CNN classifier performance,* ***(b)*** *Probability Distribution Function (PDF) of the error between the CNN tracking and ground truth in the x- and y-directions,* ***(c)*** *Example CNN monitoring compared to the CT projection position and ground truth.*

METHOD

- A real-time multiple object tracking system based on a CNN classifier was developed for intrafraction monitoring (Fig. 1).

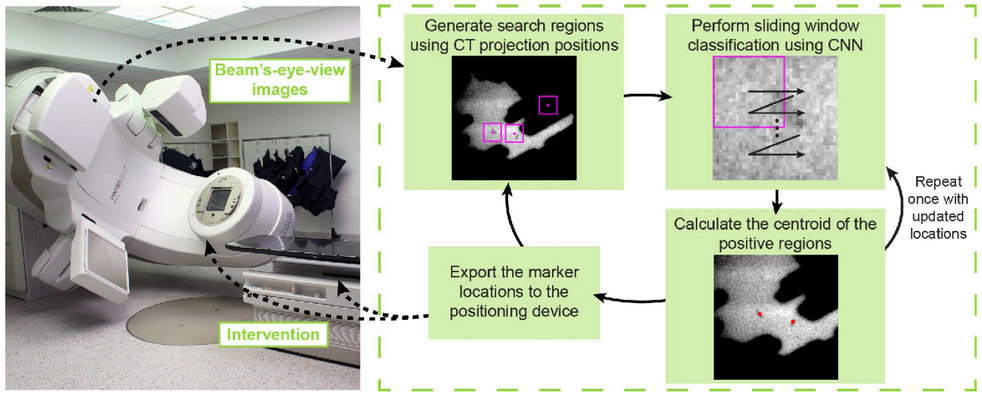

Figure 1. *Schematic of the automated CNN marker monitoring workflow.*

- The real-time tracking performance of the system was enabled by biasing the search region using the known 3D locations of the markers acquired from the patient's CT (Fig. 1).
- We trained and validated the classifier using labelled MV images of prostate cancer patients with implanted fiducials undergoing VMAT treatments (Fig. 2). The monitoring system accuracy was compared with manual identification.

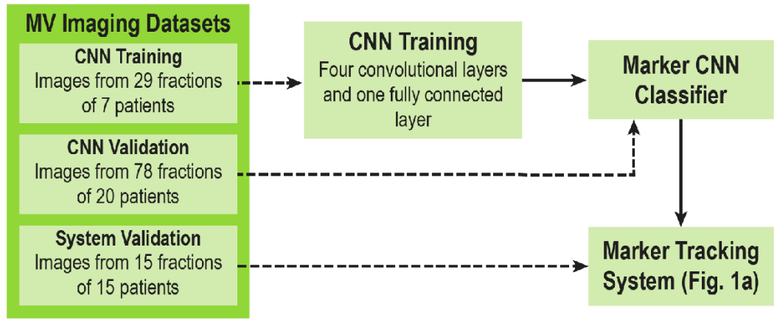

Figure 2. *Overview of the method and datasets utilised.*

CONCLUSIONS

- We present the first application of a CNN classifier in a real-time monitoring system for fiducial markers in beam's-eye-view images.
- Monitoring using beam's-eye-view images can reduce the need for kilovoltage imaging during the treatment, hence lowering the patient's imaging dose.
- The high classification performance on unseen MV images demonstrates that the classifier can successfully identify fiducial markers during different VMAT treatments.

The sub-millimetre accuracy and precision of the marker tracking system demonstrates that it can be feasibly used for real-time monitoring applications.

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