Development of an inexpensive patient setup and monitoring system using an open source, GPU computed, deep learning algorithm

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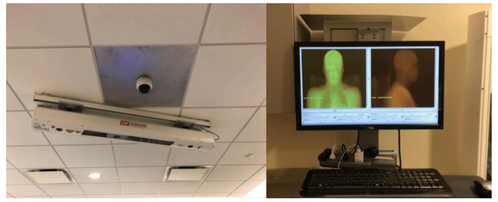
INTRODUCTION

In Proton Therapy, accurate beam delivery is very important. Therefore many proton centers use verification CTs (vCT) to monitor volumetric changes. We have developed a system that registers scout and surface images from video cameras taken at the planning CT(pCT) and vCT. We have extended the system to detect motion by interfacing the video camera with artificial intelligence (AI) computer vision software so that we are objectively monitoring intra-fractional motion during the treatment.

METHOD

Developed surface image tool using a pair of orthogonally placed inexpensive video cameras using opensource programs - python(v3.7)[1], OpenCV(v4.2)[2] and PyQt(v5)[3].

- A pair of reference images of the patient setup is captured from video cameras using surface image tool during initial simulation and acts as a reference position for the therapists during the vCT.
- During vCT process, the 2D surface imaging tool is used for initial guidance of the patient setup with help of image fusion and edge effect functionality.
- Additionally, for fine tuning the setup, using 2D surface tool can fuse pCT to vCT Scout images, mimicking treatment alignment (IGRT) of bony landmarks, prior to CT scanning to obtain optimal setup for vCT.



RESULTS

The registration tool has improved the vCT registration quality based upon comparisons of vCT/pCT pairs for the same site before and after introduction of the tool. The initial results of the patient tracking system will be presented and show potential for monitoring patient motion objectively.

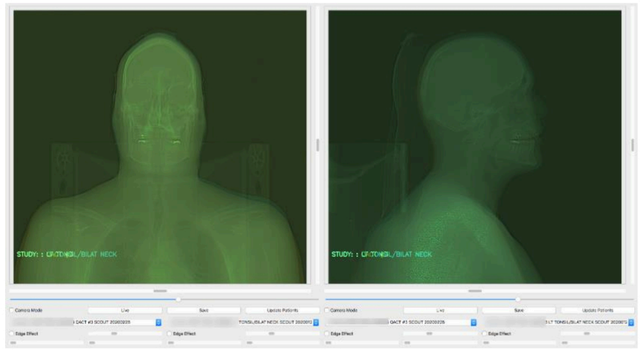


Figure 1: The interface of Surface/Scout image tool. This allows to show overlaid images from surface image and live video or Scout images. We can change blending of images with the horizontal bar below the images and buttons for live video or capture the screen from live video directly. Patient monitoring system is implemented in live video.

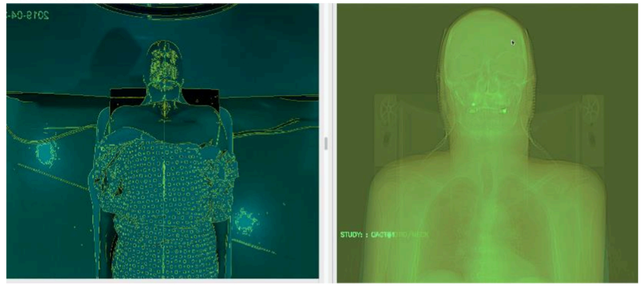


Figure 2: Left: Surface image of vCT overlaid with one from Planning CT (pCT) with edge effect during initial simulation. Right: Scout image of vCT overlaid with one from pCT.

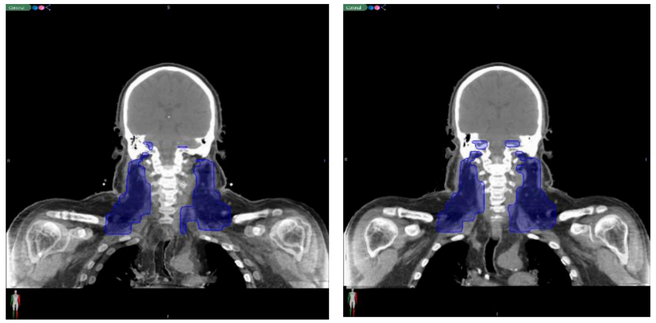


Figure 3: Left: vCT overlaid with pCT prior using Surface/Scout image tool. Right: vCT overlaid with pCT after using Surface/Scout image tool.

For the patient monitoring, we are implementing/testing object tracking algorithm[4] based on Deep Learning Algorithm. For real-time tracking, we used GPU computed algorithm based on NVIDIA CUDA DNN libraries[5]. Frame per Second (FPS) is reasonably accelerated with GPU computed Deep learning algorithm[6].

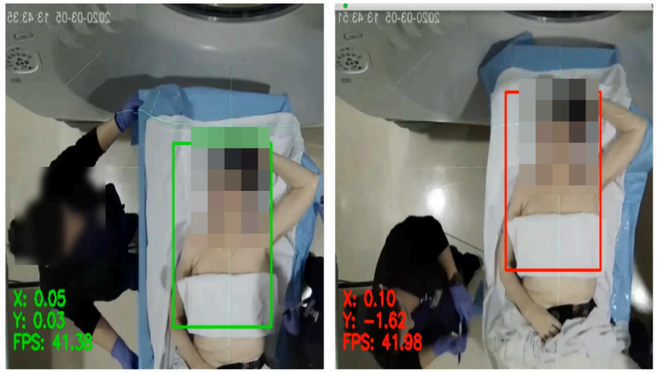


Figure 4: These pictures demonstrate the patient monitoring system is tracking the patient in real-time with green box (left) and alerts to the therapist with red box when it detects patient movement that exceeds its tolerance.

CONCLUSIONS

We have developed an inexpensive x-ray and surface imaging based system for vCTs which could be generalized in treatment room use for both protons and photons. The use of emerging deep learning and computer vision developments provides the opportunity for surface imaging and monitoring systems. AI potentially permits clinics to create their own training sample for the patient setups and customize the tolerances intra-fractional patient motion.

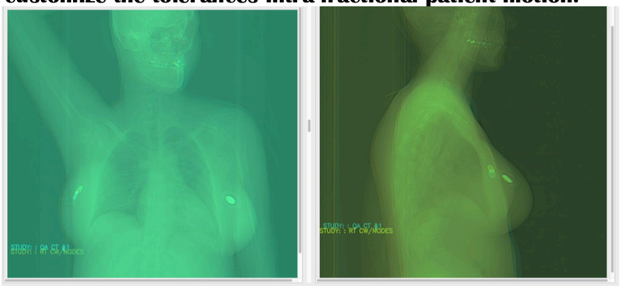


Figure 5: Coronal and Sagittal view of Scout image of vCT overlaid with one from pCT to verify the displacement of Breast expander.

REFERENCES

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6. NVIDIA CUDA 10.1 https://developer.nvidia.com/cuda-gpus

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