By seamlessly integrating treatment simulation and planning into the treatment delivery process, online adaptive radiotherapy (ART) allows real-time treatment adaptations based on the current patient anatomy and therefore holds significant promise in maximally compensating for anatomical uncertainties. This new paradigm of cancer radiotherapy provides an opportunity to significantly reduce normal tissue toxicity and/or to improve tumor control. Additionally, online ART can also handle the interfraction variation of the organ motion pattern, the inaccuracy of patient positioning (fast but less accurate patient positioning is then allowed), direct treatment without a traditional CT simulation, and the change of treatment strategy in the middle of the treatment course. However, the clinical realization of online ART is extremely challenging, mainly due to three major barriers: the inability for real-time treatment re-planning, the concern of excessive imaging dose from daily CT/CBCT, and the lack of an efficient clinical workflow. To overcome these barriers, we have been developing a series of GPU-based computational tools for real-time re-planning, GPU-based low-dose CT/CBCT reconstruction, and an innovative computational infrastructure for a streamlined clinical workflow. In this talk, we will discuss the current status of this effort and some initial clinical applications.

This lecture will provide an overview of the technical barriers for the clinical realization of online adaptive radiotherapy as well as the current efforts to overcome these barriers.

Learning Objectives:

1. Understand the great potential of online adaptive radiotherapy;
2. Understand the major technical barriers for the clinical realization of online adaptive radiotherapy;
3. Understand the great potential of using graphics processing unit (GPU) to achieve high computational efficiency;
4. Understand an IMRT plan can be developed in seconds using GPU-based computational tools;
5. Understand CT/CBCT imaging dose can be reduced by 1-2 orders of magnitude using new reconstruction algorithms;
6. Understand a streamlined clinical workflow can be developed for online adaptive radiotherapy.