AbstractID: 14500 Title: Machine Learning in Real-time Tumor Localization

Real-time tumor localization is an essential step to achieve conformal lung cancer radiotherapy. In practice, tumors may be localized either directly (*e.g.*, in fluoroscopy) or indirectly by some type of surrogate. Direct localization with implanted markers poses the risk of pneumothorax to lung cancer patients, while indirect localization is limited by its accuracy. Direct localization in fluoroscopy without implanted markers achieves a reasonable tradeoff between accuracy and risk to the patients. However, due to the poor soft tissue contrast and superposition of different anatomical structures, it is generally very difficult to localize the tumor in fluoroscopy with conventional methods in computer vision and image processing.

Recently, machine learning has gained great popularity in many aspects of radiation therapy. In this lecture, we will demonstrate the applications of various machine learning techniques in the context of real-time tumor localization in lung cancer radiotherapy. These cover a wide range of well established machine learning techniques, including principal component analysis (PCA), artificial neural networks, and support vector regression, *etc.*. We will distinguish between two different paradigms when applying these techniques: one in a two-dimensional (2D) framework and the other in a three-dimensional (3D) framework. In the 2D framework, a (supervised) regression model is built between a parametric representation of the fluoroscopic images and the tumor locations in the corresponding fluoroscopic images. Because the representation of the fluoroscopic images is implicit in the 2D framework, it is difficult to account for deformational and large translational changes in the tumor. In the 3D framework, by incorporating the prior information in 4DCT or 4DCBCT, a PCA model is constructed to explicitly represent the entire lung motion in a realistic and efficient way. This model allows one to use a single x-ray projection image to not only derive the 3D tumor location, but also reconstruct the corresponding volumetric image of the patient. With the aid of graphics processing units, this computationally intensive task can be achieved within half a second given one projection.

This lecture provides an overview of the different machine learning techniques used in real-time tumor localization. A detailed description of these machine learning techniques is also presented. Finally, extensions to the current framework as well as some future directions are discussed.

Educational Objectives:

1. Understand the benefits and challenges of real-time tumor localization without implanted markers.
2. Understand the principles of different types of machine learning techniques for real-time tumor localization.
3. Understand how machine learning techniques are used to achieve accurate real-time tumor localization.

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