A Robotic System for Real-Time Tumor Manipulation During Image Guided Breast Biopsy

Vishnu G. Mallapragada, Nilanjan Sarkar, and Tarun K. Podder
Vanderbilt University, Nashville, USA

Breast biopsy guided by imaging techniques is widely used to evaluate suspicious masses within the breast. Current procedure allows the physician to determine location and extent of a tumor in the patient breast before inserting the needle. There are several problems with this procedure: Complex interaction dynamics between needle and breast tissue will likely displace the tumor from its original position necessitating multiple insertions, causing surgeons' fatigue, patient's discomfort, and compromising integrity of the tissue specimen. We present a new concept for real-time manipulation of a tumor using a robotic system that monitors the image of the tumor to generate appropriate external force to position the tumor at a desired location. The objective is to demonstrate that it is possible to manipulate a tumor in real-time by applying controlled external force in an automated way such that the tumor does not deviate from the path of the needle. We have demonstrated efficacy of this approach on breast phantoms. The robotic system consists of an ultrasound probe for image acquisition, a guiding mechanism for automatic probe orientation, image processing algorithm for extracting tumor position and PID (proportional-integral-derivative) controlled actuators for tumor manipulation. We have successfully tested this system for accessing mobile lesions during multiple needle insertion trials. This approach has the potential to reduce the number of attempts a surgeon makes to capture the desired tissue specimen, minimize tissue damage, improve speed of biopsy, and reduce patient discomfort.

