Artificial Tactile Sensation Imaging for Healthcare Application

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ABSTRACT

Characterizing and locating sub-surface tumors will greatly enhance the diagnosis and treatment of breast cancer and prostate cancer. In this study, we designed and demonstrated a novel tactile sensation imaging device to detect and identify inclusions within tissues. We can use this device to more accurately identify tissues and decreasing the number of unnecessary biopsies. The advantage of this method is high resolution, low cost, portability and minimal training required to use.

I. MATERIALS AND METHODS

Diagnosing early formation of tumors or lumps, particularly those caused by cancer, has been a challenging problem. To help physicians detect tumor more efficiently, various imaging techniques with different imaging modalities such as computer tomography, ultrasonic imaging, nuclear magnetic resonance imaging, and x-rays have been developed. However, each of these techniques has limitations, including the exposure to radiation, excessive costs, and complexity of machinery. Artificial tactile sensation imaging is a valuable non-invasive tool for the medical society, where physicians use tactile sensation to identify malignant tissue. Traditionally physicians have used palpation to detect breast tumors or prostate tumors, which is based on the observation that the tissue abnormalities like tumor are usually associated with localized changes in mechanical properties such as stiffness. Artificial tactile sensation imaging can accurately visualize and record the tactile sensation of benign and malignant region. In this research, we present a newly designed tactile sensation imaging device to detect or locate sub-surface inclusions such as tumors or lumps. Polydimethylsiloxane is used to make a multi-layer optical waveguide as a sensing probe. In our device, total internal reflection principle is utilized to obtain high resolution of tactile image. A force applied to an elastic waveguide while light passes through it causes change in the critical angle of internally reflected lights. This results in diffused light outside the waveguide that has been captured by a camera. The sensitivity and the resolution of the proposed method are controlled by the size of the waveguide and the light source intensity.

II. RESULTS AND DISCUSSIONS

For a tumor detection experiment, a tissue phantom with embedded hard nodules has been developed. This phantom was made of a silicone having Young's modulus of 5~10 kPa. Two hard inclusions were placed 2 mm (Target A) and 4 mm (Target B) below the upper surface of the tissue phantom. The inclusions have Young's modulus of 100~300 kPa, higher stiffness than the surrounding phantom material. Two tactile images were obtained using the tactile sensation imaging device. To compare two tactile images, the horizontal pixel intensity through the centroid of the image is obtained and the Gaussian fitting model is used to describe the shape of pixel intensity. Fig. 1 shows the comparison result. The target A shows higher pixel intensity than target B. From the two curves, we determine the existence of the nodules and the relative depth of target A and target B. For the future work, we will investigate the relationship between different inclusion depth and tactile image and from this relationship, we will find the absolute inclusion depth.

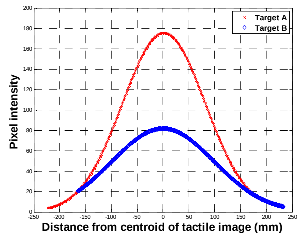

Fig. 1. Gaussian fitting models of Target A and Target B tactile image pixel intensity.