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Fusion of Deformation Index Ratio and Health Information for Breast Cancer Risk Assessment

S. Choi, D. Caroline, S. Pascarella, R. Kendzierski, C.-H. Won, *Member, IEEE*

***Abstract*—Breast cancer risk assessment based on the patient health information results in a breast cancer risk probability. The smartphone compression-induced sensing (SCIS) system generates tactile images, and these images estimate the deformation index ratio of a lesion. We estimate the breast cancer risk using the patient health record and the deformation index ratio. For a small number (eight) of patients, the malignancy of the tumor was classified based on relative risk scoring and patient health information with the sensitivity and specificity of 100%.**

Keywords: smartphone compression-induced sensing system, tactile imaging, non-invasive, deformation index ratio, cancer

I. Introduction

Breast cancer can be prevented or treated successfully if detected at the early stage, although it is the fifth leading cause of cancer-associated death worldwide [1]. Thus, periodical risk assessment and basic prescreening can improve the detection rate of breast cancer. Smartphone compression-indued sensing (SCIS) system is developed to mimic the clinical breast examination [2]. The system generates the deformation index ratio to assess the malignancy of the breast mass based on its stiffness [3]. By incorporating the breast risk assessment method using the patient health record, we expect to improve the accuracy of risk estimation.

II. Breast Cancer Risk Estimation

A. Breast Cancer Risk Estimation

Breast cancer risk is estimated as shown in Fig. 1. The breast cancer incident rate is calculated based on the patient's age and race information. The deformation index ratio indicates the lesion stiffness compared to the healthy breast tissue [2].

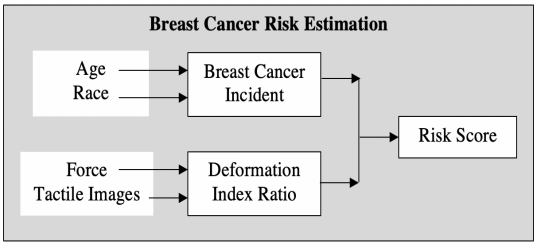

Fig. 1. Breast Cancer Risk Estimation Process

We formulate the breast cancer risk incident rate (per 100 000) using the simplified Gail model from the Breast Cancer Surveillance Consortium (BCSC) [4]. The incident calculation model is derived based on age and race using the 1998 to 2002 SEER invasive breast cancer. Equation (1) shows the incidence model $I_{x,r}$ based on age, x, and race, r from the patient health record.

$$I_{x,r} = a_r x^3 + b_r x^2 + c_r x + d_r \quad (1)$$

SCIS system provides the calculated deformation index ratio (DI_R) using the force value and the corresponding images. In the previous study [2], we used the index to classify the lesion as malignant or benign based on the stiffness of the lesion compared to the healthy tissue. R indicates the breast cancer risk level of the measured lesion based on the normalized incident (I_n) and the normalized deformation index ratio (DI_{Rn}) with a range of 0-1. P_1 and P_2 are the weights. The risk R uses a scale of 0-5 ($S = 5$).

$$R = S * (P_1 I_n + P_2 DI_{Rn}) \quad (2)$$

III. *In-Vivo* Experiments and Result

To verify the classification result, we applied the risk estimation method to the eight *in-vivo* experimental data. (P_1=0.7, P_2=0.3, threshold R>2.5). The results are given in Table I. We obtained 100% sensitivity and 100% specificity.

TABLE I. Result Risk Estimation of Human Data

Case	DI_R (benign/malignant)	Relative Risk Score (benign/malignant)	Biopsy Result
1	0.57 (b)	1.64 (b)	Benign
2	0.72 (b)	2.37 (b)	Benign
3	**1.64 (m)**	**4.44 (m)**	**Malignant**
4	0.68 (b)	1.85 (b)	Benign
5	**1.34 (m)**	**3.96 (m)**	**Malignant**
6	0.41 (b)	1.67 (b)	Benign
7	0.24 (b)	**2.63 (m)**	**Malignant**
8	**1.03 (b)**	**3.88 (m)**	**Malignant**

IV. Conclusion

Estimating the breast cancer risk using the SCIS system with the patient health record was performed for the eight human patients. For this small sample, the results showed 100% sensitivity and 100% specificity in classifying malignant tumors.

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