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A novel cognitive interpretation of breast cancer thermography with complementary learning fuzzy neural memory structure

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Abstract

Early detection of breast cancer is the key to improve survival rate. Thermogram is a promising front-line screening tool as it is able to warn women of breast cancer up to 10 years in advance. However, analysis and interpretation of thermogram are heavily dependent on the analysts, which may be inconsistent and error-prone. In order to boost the accuracy of preliminary screening using thermogram without incurring additional financial burden, *Complementary Learning Fuzzy Neural Network* (CLFNN), FALCON-AART is proposed as the *Computer-Assisted Intervention* (CAI) tool for thermogram analysis. CLFNN is a neuroscience-inspired technique that provides intuitive fuzzy rules, human-like reasoning, and good classification performance. Confluence of thermogram and CLFNN offers a promising tool for fighting breast cancer.

Keywords: FALCON-AART; Fuzzy adaptive learning control network fuzzy neural network; Thermogram; Breast cancer diagnosis; Complementary learning

1. Introduction

Breast cancer is the second most deadly cancer among women. Each year, 211,240 women are diagnosed with breast cancer and 40,870 of them will die in 2005 (American Cancer Society, 2005). In United States alone, it is estimated that there are 1 million women with undetected breast cancer; to date, the figure of women affected has surged to 1.8 million and 45, 000 women die per year (Diakides & Diakides, 2003). This high death rate has stimulated extensive researches in breast cancer detection and treatment. Recent studies have determined that the key to breast cancer survival rests upon its earliest detection possible. If discovered in its earliest stage, 95% cure rates are possible (Gautherie, 1999; Pacific Chiropractic and Research Center). On the other side, it is reported that 70 to 90% of the *excisional biopsies* performed are found to be benign (Lay, Crump, Frykberg, Goedde, & Copeland, 1990). Owing to this high false positive rate, many endeavors have been putted into ameliorate the breast cancer early detection.

Breast imaging is a noninvasive and inexpensive cancer detection technology. Amongst, mammography is accepted as the most reliable and cost-effective imaging modality. However, its false-negative rates is high (up to 30%) (Elmore, Wells, & Carol, 1994; Rajentheran, Rao, Lim, & Lennard, 2001). In addition, the danger of ionizing radiation and tissue density, which has been associated with increased cancer risk (Boyd, Byng, & Jong, 1995), is linked with patient who underwent mammography screening. It is also uncomfortable, because the breast has to be compressed between flat surfaces to improve image quality. Furthermore, obtaining adequate images from radiologically dense breasts (with little fat) or in women with breast implants are difficult (Foster, 1998), and it is difficult to detect breast cancer in young women (Gohagan, Rodes,

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Blackwell, & Darby, 2004). Despite of these limitations, mammogram remains the gold standard for screenings (Gohagan et al., 2004; Moore, 2001). Since early detection is important, new technologies such as *Magnetic Resonance Imaging* (MRI), *Positron Emission Tomography* (PET), *Computed Tomography-Single Photon Emission Computed Tomography* (CT-SPECT) (Del Guerra, Di Domenico, Fantini, & Gambaccini, 2003), and ultrasound have been applied as complement to mammogram (Ng & Fok, 2003). Fig. 1 and Table 1 show the available modalities for breast cancer detection at present, and the reported accuracy, respectively. Note that the reported accuracy is

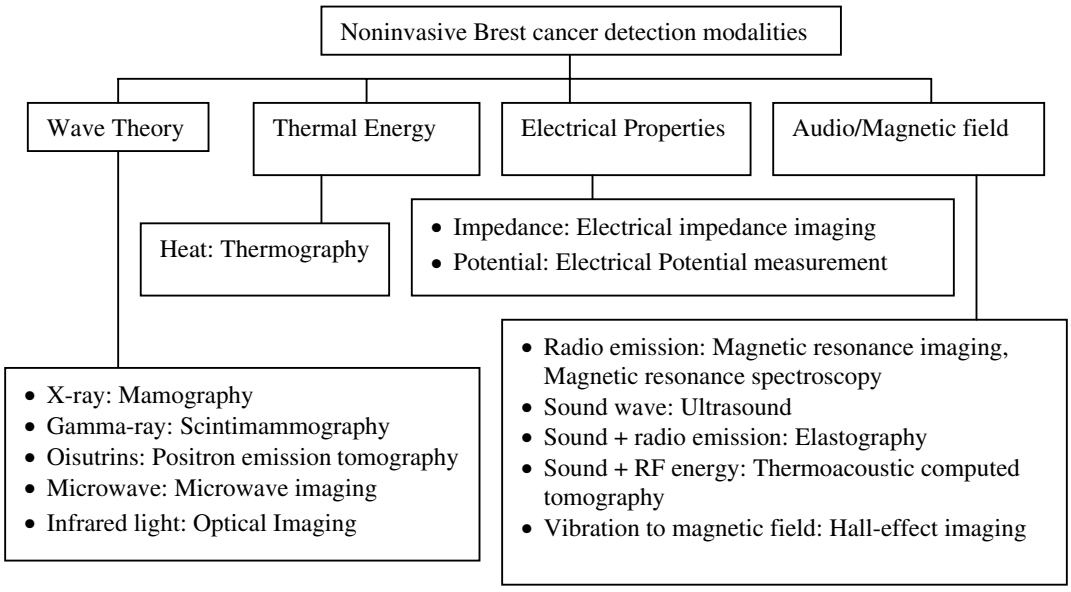

Fig. 1. Noninvasive breast cancer detection modalities (adapted from Fok et al., 2002).

Table 1
Accuracy of breast cancer diagnosis modalities

Technique	Sensitivity (%)	Specificity (%)	References
Clinical examination	48.3–59.8	90.2–96.9	Barton (2002), McDonald et al. (2004)
Biopsy			
Surgical/Open biopsy	≈100	≈100	Imaginis, Breast Cancer Diagnosis (2004)
Vacuum-assisted biopsy (Mammotome)	95	98	Simmon et al. (2000)
Large core biopsy	74–97	91–100	Delle Chiaie and Terinde (2004), Meyer et al. (1999), Puglisi et al. (2003)
FNA (biopsy)	85–88	55.6–90.5	Pisano et al. (2001)
Core needle biopsy	91–99	73–100	Brenner et al. (2001), Pisano et al. (2001)
Breast cyst aspiration	79	94	Lucas and Cone (2003)
Imaging			
FNA (cytology)	65–99	64–100	Fajardo et al. (1990), Reinikainen (2003)
Mammography	13–95	14–90	Fajardo et al. (1990), Fletcher et al. (1993), Singhal and Thomson (2004)
Full-Field Digital Mammography (FFDM)	64.3	88.2	Irwig et al. (2004), Lewin et al. (2002)
Thermography	90	90	Amalu (2003)
Ultrasound/Sonography	13–98.4	67.8–94	Houssami et al. (2003), Singhal and Thomson (2004), Stavros et al. (1995)
MRI	86–100	21–97	Cecil et al. (2001), Orel (2000), Singhal and Thomson (2004), Yeung et al. (2001)
Proton Magnetic Resonance Spectroscopy (MRS)	83–100	73–87	Cecil et al. (2001), Reinikainen (2003), Yeung et al. (2001)
Scintigraphy (CT)	55–95	62–94	Brem et al. (2003), Singhal and Thomson (2004)
PET	96	100	Singhal and Thomson (2004)
Positron Emission Mammography (PEM)	80–86	91–100	Levine et al. (2003), Murthy et al. (2000)
Electrical Impedance Scanning (EIS)	62–93	52–69	Glickman et al. (2002), Malich et al. (2003)
Gene screening			
Serum protein expression profiling	90	93	Vlahou et al. (2003)
Gene Profiling	83–91	72.7–81.8	van't Veer et al. (2002)
Gene Testing	63–85	Not mentioned	Berry et al. (2002)