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Background intensity independent texture features for assessing breast cancer risk in screening mammograms

Xi-Zhao Li *, Simon Williams [1], Murk J. Bottema [2]

School of Computer Science, Engineering and Mathematics, Flinders University, Bedford Park 5042, SA, Australia

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ABSTRACT

Image intensity and texture in screening mammograms are thought to be associated with the risk of breast cancer. Studies on developing automatic breast cancer risk assessment schemes tend to employ texture measures which are correlated to local background intensity. Accordingly, the contribution of texture alone to risk assessment is not known. Here background intensity independent texture measures are used to assess cancer risk. Moreover risk assessment based on background intensity independent texture outperforms intensity dependent texture suggesting that local image background intensity may confound risk assessment. Performance seems to depend on the view of the breast and so suggests that optimizing schemes for different views may improve risk assessment.

1. Introduction

In the earliest period of mammogram analysis, parenchymal (the functional tissue of the breast such as milk ducts and glands) patterns were considered to indicate the risk of breast cancer (Wolfe, 1976b). Wolfe was the first to study breast cancer risk based on mammographic appearance. He proposed four categories of breast parenchymal patterns and the corresponding probability of developing breast cancer (Wolfe, 1976a). The four patterns are N1, P1, P2 and DY. In N1, parenchyma is composed primarily of fat with at most small amounts of dysplasia (enlargement due to proliferation of abnormal cells) and is related with lowest risk. The P1 pattern is a low risk pattern and the parenchyma is chiefly fat with prominent ducts limited to the anterior portion of the breast and to less than one forth of the total breast volume. Also, there may be a thin band of ducts extending into another quadrant. For P2, the breast is involuted with prominent ducts patterns occupying more than one-fourth of the volume of the breast. P2 is considered as a high risk class. In the DY category, the breast has severe involvement with dysplasia and often obscures an underlying prominent duct pattern. This pattern has the highest risk of breast cancer. Wolfe pattern classes were widely accepted when first proposed. The reason may be breast cancer mostly arises from the epithelial (tissue forming the outer layer) lining of the ductal/lobular glands (Wellings et al., 1975). The observations by Wolfe were initially supported by other studies (Saftlas et al., 1989; Brisson et al., 1981).

However, numerous studies and alternative interpretations of Wolfe's results cast doubt on his original conclusions linking parenchymal patterns and breast cancer risk. Subsequent studies did not reproduce odds ratios as great as those reported by Wolfe and some even failed to find evidence of a relationship between Wolfe's classification and the risk of breast cancer. Egan (Egan and Mosteller, 1977; Whitehead et al., 1985) applied Wolfe's findings to a masking phenomenon in which mammograms of dense breasts failed to reveal developing cancers as effectively as fatty breast mammograms. Mendell et al. (1977) and Whitehead et al. (1985) also objected to the experimental design of Wolfe's studies. In the follow up to Wolfe's study (Saftlas et al., 1989), first-degree family history of malignancy together with parenchymal patterns were considered as breast cancer risk indicators.

At the same time, a number of studies assessed the correlation between breast patterns (including densities), and breast cancer risk. These studies showed that breast density is one of the strongest predictors for the risk of developing breast cancer (Byng et al., 1996; Boyd et al., 1995; McCormack and dos Santos Silva, 2006; Whitehead et al., 1985) and is independent of other risk factors.

More recently, another classification was proposed by American College of Radiology (BI-RADS) (American College of Radiology, 2003). The BI-RADS classes are a modified version of the Wolfe classes that shift focus from structure patterns to the amount and distribution of dense tissue (Fig. 1). The four classes are:

* Corresponding author. Tel.: +61 8 82017927.
E-mail addresses: li0691@flinders.edu.au (X.-Z. Li), s.williams@flinders.edu.au (S. Williams), murk.bottema@flinders.edu.au (M.J. Bottema).
[1] Tel.: +61 8 82012037.
[2] Tel.: +61 8 82013652.

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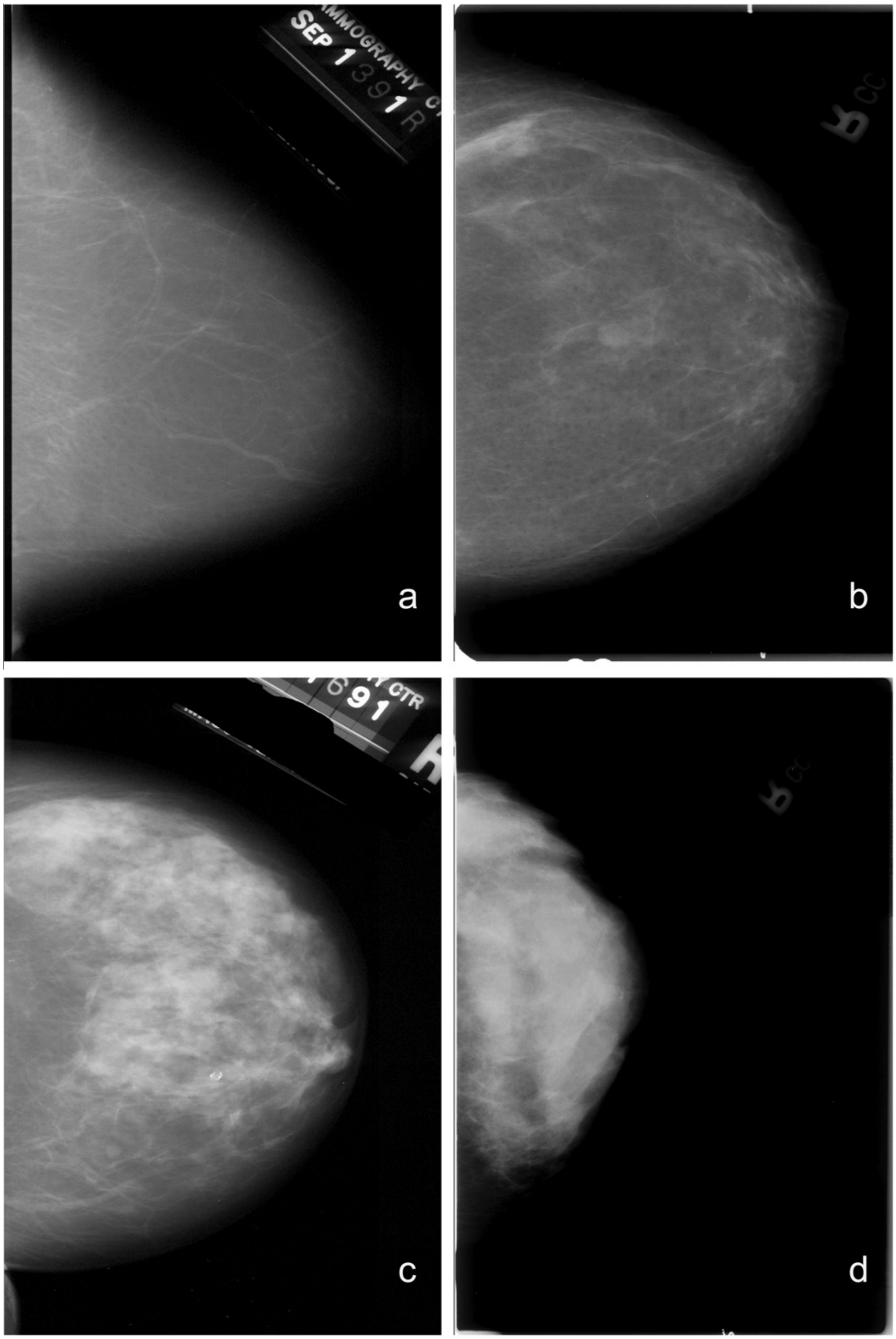

Fig. 1. Examples of mammograms from the four BI-RAD pattern categories: a) BI-RAD I, b) BI-RAD II, c) BI-RAD III, d) BI-RAD IV.

I. The breast is almost entirely fat.
II. There are scattered fibro-glandular densities.
III. The breast is heterogeneously dense. This may lower the sensitivity of mammography.
IV. The breast tissue is extremely dense, which could obscure a lesion in mammography.

Generally, density classes BI-RADS I and BI-RADS II can be taken as a low density classes while density classes BI-RADS III and BI-RADS IV are categorized as high density classes.

Visual assessment of mammographic patterns has remained controversial due to the subjective nature of human assessment. Computer vision methods can achieve objective measurement of