Deep Learning-Based Breast Density Categorization in Asian Women

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Master's Thesis Description

Breast cancer is a significant global health concern, and its prevalence and impact are particularly notable among women. In 2020, with an expected 2.3 million new cases, female breast cancer surpassed lung cancer as the leading cause of worldwide cancer incidence, accounting for 11.7% of all cancer cases and resulting in approximately 685,000 deaths globally [1]. Notably, breast cancer constitutes one in every four cancer cases and one in every six cancer deaths among women [1].

A significant risk factor contributing to the breast cancer burden is the incidence of mammographic dense breast tissue [2]. Breast density is the percentage of dense tissue in a breast. For women who have high breast density, there are two major challenges. First, high breast density reduces the cancer detection sensitivity of screening mammography by masking underlying lesions [2]; second, breast density is an independent risk factor for breast cancer. [2]. The necessity of reliable breast density reporting has been further increased after the US legislation obligated that women be informed of their breast density because decisions concerning additional screening with US and MRI are based on mammographic density [3]. In clinical practice, breast density is visually determined using two-view mammograms by employing the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) four-category scale: a (almost entirely fatty), b (scattered fibroglandular), c (heterogeneously dense), and d (extremely dense) [4]. However, this and other classification methods are affected by variability among readers and between countries [5, 6]. Completely automated approaches using deep neural networks have been introduced to enhance breast density classification, yielding contrasting outcomes [7–9].

This research initially places its focus on Asian women, who generally exhibit higher breast density compared to European and American populations [10]. This distinction is particularly significant given that most existing automated breast density categorization methods are developed using data from Western populations [8, 9], where high breast density is less prevalent. Consequently, there is uncertainty regarding the applicability of these methods, designed for Western populations, to accurately assess breast density in Asian women. Considering the distinct mammographic and clinical features between Asian and Western women, there is a clear need for improved methods of breast density categorization tailored to Asian women. Within this context, the VinDr-Mammo dataset from Vietnam serves as a valuable representative subset of the broader Asian demographic [11]. This dataset, a large-scale publicly available full-field digital mammography dataset with breast density reporting as per the ACR guidelines, therefore provides a crucial resource for developing and testing these automated systems [12]. Only a handful of studies have employed the VinDr-Mammo dataset in the task of breast density classification, primarily leveraging deep learning systems based on convolutional neural network architectures. [7]. However, the performance of the methods seems sub-optimal [7]. Some approaches for automatic breast density classification have explored self-supervised learning methods to improve the performance [13]. Self-supervision techniques are known to increase performance and improve data-efficient generalization in medical image classification tasks [14, 15].

During the course of this work, an automatic deep-learning algorithm for efficient breast density categorization will be developed. The VinDr-Mammo and Siemens Healthineers Internal Dataset (Multi Reader Annotations) will be utilized for this purpose. Consequently, the thesis will consist of the following work items:

- Comprehensive literature review of the state-of-the-art breast density categorization methods using deep-learning and self-supervised learning techniques.
- Development of supervised deep-learning algorithms for breast density categorization using VinDr-Mammo dataset and Siemens Healthineers internal dataset.
- Impact of SSL method for enhanced breast density categorization.
- Inter-reader variability study in the Siemens Healthineers internal dataset and its influence on the performance of deep-learning algorithms for breast density categorization.

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