Guided Attention Mechanism for Weakly-Supervised Breast Calcification Analysis

Akshat Shrivastava

Supervisors: Adarsh Bhandary Panambur, Mathias Öttl
Prof. Dr.-Ing. habil. Andreas Maier

Master's Thesis Description

Breast cancer is the most common cancer in women in both developed and developing countries. The incidence of breast cancer has steadily risen in the past few decades, making it the most commonly diagnosed cancer worldwide in 2020, with an estimated 2.3 million cases of new incidences [1]. Early detection of breast cancer results in increased survival rates, thereby extending the patient's life expectancy. The most common breast screening modality is mammography. Mammography utilizes low-dose X-rays to examine the breast and is the most reliable method for screening abnormalities in the breast tissue [2]. Calcium deposits in breast tissue manifests into calcifications, and appear as white dots on the mammogram images. Most breast calcifications are benign, but clusters of calcium deposits can indicate early breast cancer. According to some studies, doctors recall 12.7 % to 41.2 % of women in screening programs who have breast calcifications as the only warning sign of cancer [3].

The sensitivity of calcification detection during initial mammography screening is low. Therefore, computer-aided diagnosis (CAD) techniques may aid clinicians in making better diagnostic decisions for the analysis of calcifications. Algorithms based on deep learning (DL) have proven to be an effective solution for automated breast cancer analysis in mammography. Many new methods using Convolutional Neural Networks (CNN) have shown promising performance in classifying and localizing abnormalities in mammogram images, including the calcifications [4]. However, many studies use CNN classifiers trained on labeled image patches instead of full mammogram images because of the loss of image details belonging to calcifications from resizing at input layers [5].

Localization and segmentation of lesions using deep learning would involve the acquisition of pixel-level labels. Obtaining such labels, however, is time-consuming, expensive, and necessitates medical expertise. Interpretability in DL using only image-level labels can be beneficial if the region of the input image responsible for the output can be localized and analyzed in a weakly supervised way. Attention mechanism can prove to be helpful to overcome this problem. Attention mechanism in machine learning is a technique that mimics cognitive attention and is defined as the ability to select and concentrate on relevant information. In this context, techniques such as Gradient-weighted class activation mapping (Grad-CAM) can be used to show the region of interest and highlight the calcification regions recognized by the model [6, 7]. Attention mechanism can also be used to perform weakly-supervised segmentation of high-resolution mammogram images for breast cancer diagnosis. A novel neural network architecture proposed by [8] uses coarse-level localization to identify regions of interest, which are then used for fine-grained segmentation. This model is validated using a large clinical dataset [8] and achieves promising results, even though calcifications are not exclusively analyzed. Interpretability using attention mechanism for breast calcification analysis in mammography might prove to be beneficial due to the lack of sufficient research, which forms the basis for our research.

During this thesis, we aim to perform classification and weakly-supervised localization of benign, malignant, and benign-without-callback calcifications in whole mammogram images using a guided attention mechanism. The calcification subset of the Curated Breast Imaging Subset of Digital Database for Screening Mammography (CBIS-DDSM) dataset consisting of 1546 scanned film mammography images [9] will be utilized to train and validate the deep learning algorithm. Consequently, the thesis will consist of the following work items:

- Literature review of state-of-the-art weakly-supervised deep learning methods for breast cancer analysis.

- Training, validation and visualization (Grad-CAM) of baseline deep learning algorithms for the classification and localization of breast calcifications on whole mammogram images.
- Development of a weakly-supervised guided attention mechanism method to analyze mammogram images for the improvement of:
  - Classification performance
  - Localization of the calcifications

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