

COMPUTER-AIDED DETECTION (CAD) BERBASIS INTENSITY CORRELATION ANALYSIS (ICA): DETEKSI MASSA PADA FILM DIGITALISASI MAMOGRAM

Lina Choridah¹, Nurhuda Hendra Setyawan¹, Faisal Najamuddin², Hanung Adi Nugroho²

¹Departemen Radiologi, Fakultas Kedokteran, Universitas Gadjah Mada, Yogyakarta, Indonesia

²Departemen Teknik Elektro dan Teknologi Informasi, Universitas Gadjah Mada, Yogyakarta, Indonesia

Computer-Aided Detection (CAD) Based Intensity Correlation Analysis (ICA): Detection of Masses in Digitized Film Mammograms

ABSTRACT

Objectives: Mammography has an important role in the diagnosis of breast cancer. computer-aided detection (CADe) or computer-aided diagnosis (CADx) systems have been developed to improve the capability of radiologists to interpret medical images and to differentiate benign and malignant lesions. We studied the capability of ICA as a technique used in CAD systems.

Methods: An observational study involving 20 participants (5 radiologists and 15 last year radiology residents) has been initiated. First, they performed assessment of the 60 digitized film mammograms consisting of 27 normal and 33 abnormal mammograms. Subsequently, from the 33 mammograms with pathological massed, they were asked to differentiate benign and malignant lesions (15 and 18 mammograms, respectively).

Results: The sensitivity to detect the abnormal lesions in the mammograms was 70% and the specificity was 72.78%, increased to 74% and 88%, respectively when using ICA. The sensitivity and specificity to differentiate between benign and malignant lesions turned from 40.8 % and 80.3% to 62.5% and 68% after using ICA. The missed diagnostic rate in mammography increased especially in dense breast.

Conclusion: ICA improves the radiologists detection of abnormal lesions in mammograms so that it can properly be used as CADe. However, ICA might not be used as a CADx.

Keywords: CADe, CADx, ICA, mammogram, breast cancer

ABSTRAK

Tujuan: Mamografi memiliki peran penting dalam diagnosis kanker payudara. Sistem deteksi dibantu komputer (*Computer-Aided Detection* - CADe) atau diagnosis dibantu komputer (*Computer Aided Diagnosis* - CADx) telah dikembangkan untuk meningkatkan kemampuan dokter spesialis radiologi dalam menafsirkan gambar medis dan untuk membedakan lesi jinak dan ganas. Kami mempelajari kemampuan ICA sebagai teknik yang digunakan dalam sistem CAD.

Metode: Penelitian observasional ini melibatkan 20 peserta (5 dokter spesialis radiologi dan 15 residen radiologi tahun terakhir). Pertama, mereka melakukan penilaian terhadap 60 mamogram film digital yang terdiri dari 27 mamogram normal dan 33 abnormal. Selanjutnya, dari 33 mamogram abnormal, mereka diminta untuk membedakan lesi jinak dan ganas (masing-masing 15 dan 18mamogram).

Hasil: Sensitivitas untuk mendeteksi lesi abnormal dalam mamogram adalah 70% dan spesifisitasnya 72,78%, meningkat menjadi 74% dan 88% bila menggunakan ICA. Sensitivitas dan spesifisitas untuk membedakan antara lesi jinak dan ganas berubah dari 40,8% dan 80,3% menjadi 62,5% dan 68% setelah menggunakan ICA. Tingkat diagnostik yang tidak tepat dalam mamografi meningkat terutama pada densitas payudara padat.

Kesimpulan: ICA memperbaiki kemampuan dokter spesialis radiologi untuk mendeteksi lesi abnormal dalam mamogram sehingga bisa digunakan sebagai CADe. Namun, ICA mungkin tidak cocok digunakan sebagai CADx.

Kata kunci: CADe, CADx, ICA, mamogram, kanker payudara

INTRODUCTION

Breast cancer is the most frequent cancer among women with an estimated 1.67 million new cancer cases diagnosed in 2012 (25% of all cancers). It is the most common cancer in women both in more and less developed regions with slightly more cases in less developed (883,000 cases) than in more developed (794,000) regions.^{1,2,3} The incidence rate increases continuously each year therefore breast cancer becomes one of the major health problems in Indonesia.⁴

Mammography is a low-dose x-ray procedure that allows visualization of the internal structure of the breast. Conventional (film) mammography has been largely replaced by digital mammography, which appears to be even more accurate for women younger than age 50 and for those with dense breast tissue.³ Digital image can be transmitted over a data network and archived digitally and can be delivered through the facilities of Picture Archiving and Communication System (PACS). Another advantage is the presence of more complete information on the image. Digital image can be observed and improved by software such as its contrast, brightness, filtration and magnification.⁵

In screening mammographic examination, non-cancerous lesions can be misinterpreted as a cancer (false-positive value), while cancers may be missed (false-negative value). As a result, radiologists fail to detect 10% to 30% of breast cancers.^{6,7} Computer-aided detection (CADe) or Computer-aided diagnosis (CADx) systems have been developed to improve the capability of radiologist in interpretation of medical images and differentiation between benign and malignant lesions.

Digital Mammography is usually equipped with CADe and CADx system.⁶

Indonesia is the developing countries that have limited mammography and most of the mammography unit are analog systems. Yogyakarta, one province of Indonesia only has 5 mammography equipments. Our hospital has one analog mammography. Based on these limitations, in collaboration with the department of electrical engineering, we developed a CAD system based Intensity Correlation Analysis (ICA). In this study, we studied capability of ICA as one of the technique used in CAD systems.

METHOD

An observational study involving 20 participants (5 radiologists and 15 final-year of radiology residents) was initiated to conduct an assessment of the analog mammograms using the ICA system. Mammography digitized using a digitizer from the production house Faculty of Medicine Universitas Gadjah Mada. Digitized Mammograms are processed using the ICA system.

The approach in this work is described as follows. The first step of the research is to detect the abnormal area in images. The second step is to differentiate between benign and malignant mammograms. The third enhance the poor quality of the image. This step aims to make the mammogram image clearer and namely as pre-processing. The fourth step is applying the ICA algorithm, the final step is analyzing the result by statistical method of sensitivity and specificity. Flowchart of the approach in computational technique is illustrated in Figure 1.

Enhancement the contrast of image is an important issue in low-level of the image. The objectives of this step is to improve the poor quality of the image. Before the digitized mammogram image is enhanced, firstly image was converted from RGB to gray scale. The aims is to simplify the contrast enhancement process, thus to compute the probability of histogram values easier with two-dimensional scales. Contrast Limited Adaptive Histogram Equalization (CLAHE) method is used to enhance the local contrast of an image. By applying this method, the uniform distribution of the image can be obtained. To remove the noise of the image, median filtering is proposed. This method is superior than another simple filtering like mean filter. It is better at preserving sharp high-frequency detail (i.e

edges) and also eliminating noise, especially isolated noise spikes (like "salt and pepper character"). The enhancement process of the mammogram images is illustrated in Figure 2.

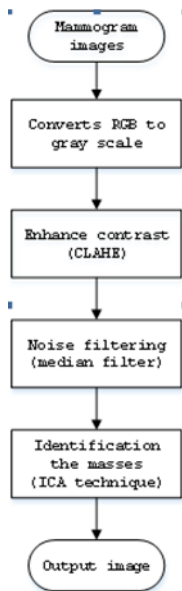


Figure 1. Flowchart of the proposed method

Intensity correlation analysis (ICA) is applied to the digitized mammogram image that have been enhanced before. The basic concept of ICA is for colocalization by comparing how the intensity of two signals vary with respect to each other, i.e. it tests their synchrony. The definition can be split into two different phenomena, co-occurrence, which refers to the presence of two (possibly unrelated) fluorophores in the same pixel, and correlation, a much more significant statistical relationship between the fluorophores indicative of a biological interaction.⁷

RESULT AND DISCUSSION

Sixty digitized mammograms consisting of 27 normal and 33 abnormal mammograms (15 benign and 18 malignant masses). The sensitivity to detect the abnormal area in images is 70% and specificity 72.78% increased to 74% and 88% respectively after using ICA. The sensitivity to differentiate between benign and malignant is 40.8% and specificity 80.3% turned into 62.5 % and 68% using ICA.

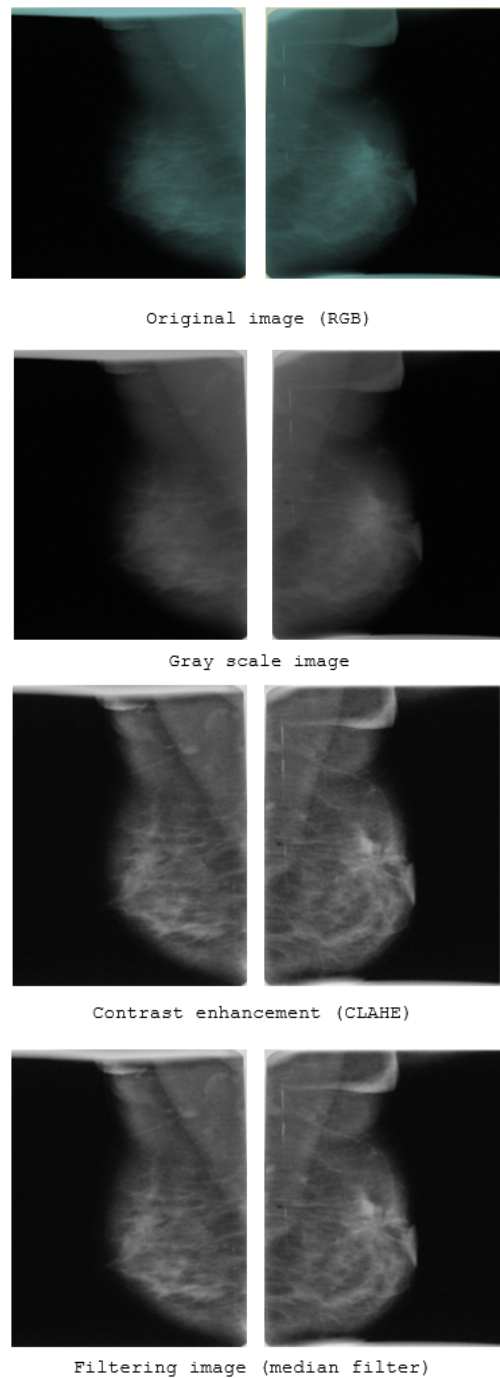


Figure 2. Enhancement process of digitized mammogram image

Generally, CAD systems are classified into two categories: computer-aided detection (CADe) and computer-aided diagnosis (CADx) systems. The CADe systems are developed to help the radiologist in detecting and locating the abnormal area in images,

while the CADx systems are designed to diagnose and classify benign or malignant tissues.^{6,8}

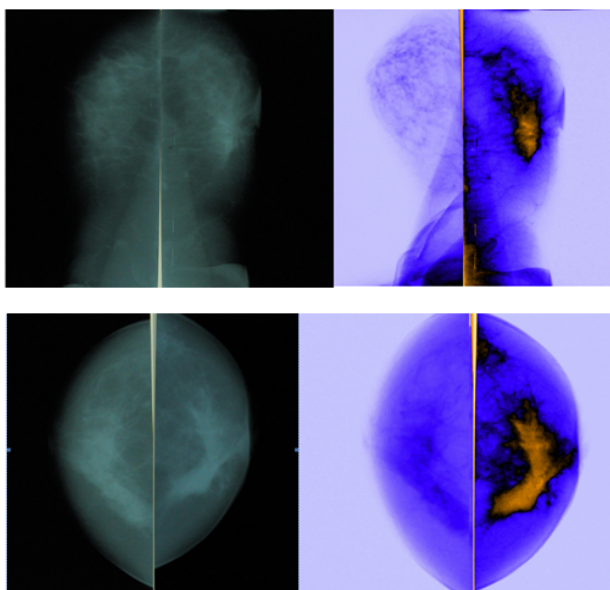


Figure 3. Abnormality detection using Cade (ICA system)

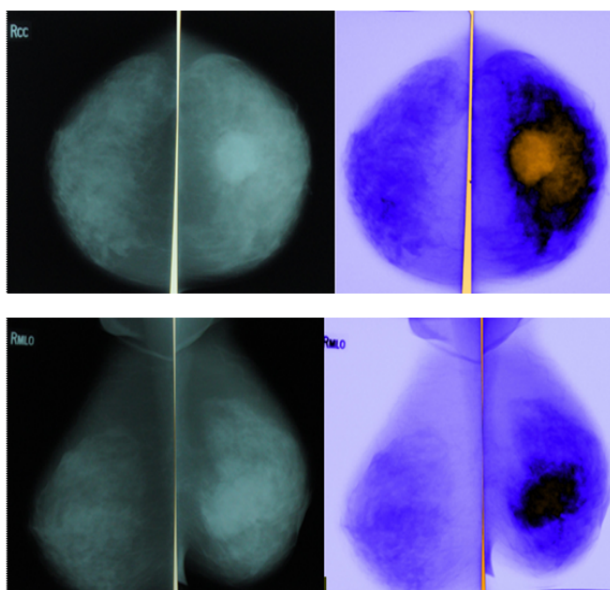


Figure 4. Malignant lesion using ICA system

At first phase, we investigated CAD capabilities using ICA as CAdE. Increasing sensitivity and specificity after using ICA demonstrates the effectiveness of ICA system in improving the radiologist's to detect the mammogram abnormalities. ICA is one of many different types of CAD systems to detect lesions in medical imaging.

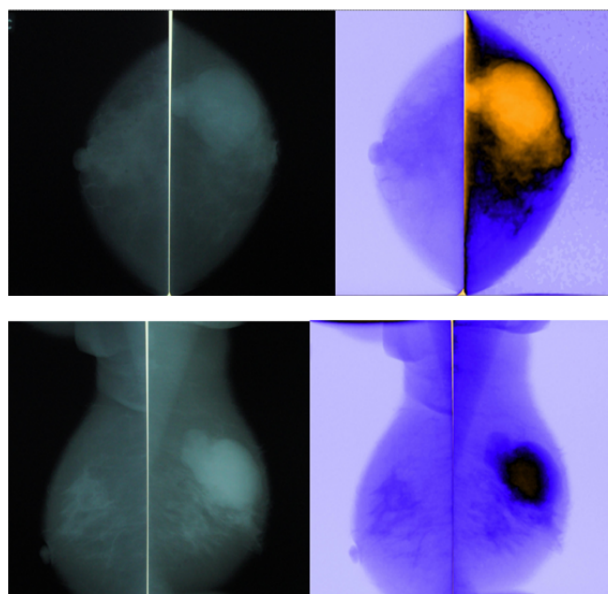


Figure 5. Benign lesion using ICA system.

The most common algorithms to identify the regions of interest (ROIs) are pixel-based or region-based methods.^{9,10} The main advantage of pixel-based methods is their simple implementation, while their significant drawback is their computationally intensive process. In region-based detection techniques, ROIs are extracted by segmentation techniques. Since region-based methods consider morphology and size of masses, they have lower computing complexity than pixel-based methods.^{9,10} The most important stages of mass detection algorithms include detection of suspicious regions and classification of suspicious area as normal tissues or masses.

The aim of second phase is to determine whether the CAD based ICA is able to help the radiologist to differentiate benign and malignant lesions, or used as a CADx. CADx systems characterize suspicious lesions to reduce the number of biopsy recommendations on benign lesions. Computer vision and artificial intelligent techniques are used to characterize an ROI as benign or malignant. To create a CADx system, the integration of various image processing operations, such as image segmentation, feature extraction, feature selection, and classification, is essential. This study did not result in increased sensitivity and specificity assessment to differentiate benign and malignant lesions.

The low ability of ICA as CADx likely can be due to some reasons. The first, we used digitized analog mammogram. The data are analog mammograms

that are digitized with possibility of decreased image quality. The second, high density mammogram can lead to a masking effect. The miss rate in mammography is increased in dense breasts where the probability of cancer is four to six times higher than in non-dense.¹⁰ Our previous studies have revealed that Javanese women with 25-34%, 35%-49%; 50%-64%; and >65% percentage mammographic density have a relative risk 1.667 (95% CI 0,47-5,89), 3,4 (95% CI 1,16-9,97), 3,43 (95% CI 1,19-9,88) and 3,45 (95%CI1,174-10,14) respectively compared to <25% percentage mammographic density.¹¹ Due to intrinsic limitations, in conventional mammography, the malignant tissues may be hidden particularly in dense breast. In order to enhance sensitivity of mammography, complimentary modalities such as ultrasound and magnetic resonance imaging (MRI) are recommended to achieve additional and adequate information.^{10,12}

Another complicating factor in differentiating benign and malignant lesions is the increasing number of high-grade invasive ductal carcinoma which have a rounded shape with distinct borders that resemble benign lesions. High grade invasive ductal carcinoma has a different picture with the low grade. The most common mammographic primary signs of low grade invasive ductal carcinoma is a mass with irregular shape, ill-defined or spiculated margins.^{12,13}

CONCLUSION

ICA improves the detection of abnormalities in mammograms so that it can potentially be used as CADe. ICA could not be used as a CADx.

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