# Breast Cancer detection Using Convolutional Neural Networks for Mammogram Imaging System

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*Abstract*— **In this paper, breast cancer detection using convolutional neural network for mammogram imaging system is proposed to classify mammogram image into normal, benign(non-cancerous abnormality) and malignant (cancerous abnormality). Breast Cancer detection Using Convolutional Neural Networks (BCDCNN) is aimed to speed up the diagnosis process by assisting specialist to diagnosis and classification the breast cancer. A series of mammogram images are used to carry out preprocessing to convert a human visual image into a computer visual image and adjust suitable parameter for the CNN classifier. After that, all changed images are assigned into CNN classifier as training source. The CNN classifier will then produce a model to recognize the mammogram image. By comparing BCDCNN method with Mammogram Classification Using Convolutional Neural Networks (MCCNN), BCDCNN has improved the accuracy toward classification on the mammogram images.Thus, the results show that the proposed method has higher accuracy than other existing methods, mass only and all argument have been increased from 0.75 to 0.8585 and 0.608974 to 0.8271 accuracy.**

## I. Introduction

Breast cancer is an important risk that must be concerned by everyone around the world. With almost 1.7 million new cases diagnosed in 2012, breast cancer is the most common form of cancer around the world [1]. In 2017, estimated 252,710 new invasive breast cancer cases will be developed in women, along with 63,410 of non-invasive breast cancer case, and 40,610 case breast cancer deaths [2]. There are many breast cancer risk factors, such as family history, medical history, and age.

According to a study for Breast Cancer Care, we have discovered that 42% of National Health Service (NHS) trusts say that they do not have the staff to assign individuals with limited breast cancer specialist nurse [3]. It is the most important reason that can cause low survival rate of breast cancer all around the world. Due to lack of breast cancer specialist nurse or doctor, it will cause late diagnosis of breast cancer, lack of compliance to optimal detection or treatment, and inequity of access to optimal treatment. Therefore breast cancer detection is developed to perform effectiveness in both abnormalities and classification breast detection. This is to assist and diagnose the breast cancer.

Diagnostic medical imaging is the most fundamental approach in the act of current solution. There are a lot of methods to obtain medical image, such as Magnetic Resonance Imaging (MRI), mammography, X-ray, and Ultrasound. Normally, mammography and MRI are used for breast cancer diagnosis. Besides, mammogram is a fast procedure which takes only about 20 minutes. The whole process is just an extremely small measure of radiation exposure from a mammogram which is safe than other treatment [4]. Moreover, late treatment will leave irreversible effects on the patient's health. Mammogram is chosen to solve the problem to increase the percent of women being treatment.

A new approach of image recognition system with breast cancer detection is proposed. This image recognition system is using convolutional neural network, which is a type of artificial neural network designed and successfully used to recognize visual imagery. This system is able to classify and detect abnormalities in mammograms image. In general, a mammogram image can be classified into malignant (cancerous abnormality), benign (non-cancerous abnormality), or normal.

Googles open source Machine Learning library, TensorFlow is used for this model [5]. This classifier tested data is obtained from mini-Mammographic Image Analysis Society (mini-MIAS) database. This classifier has been modified, through some methods, such as pixel size of input image, kernel size, learning rate, step number, number of hidden layers, and other.

## II. Problem Statement

Some previously completed research was used to understand the types of breast cancer, types of medical image used for classification, types of neural network for image classification. Tensorflow tutorial on Convolutional Neural Network is official method that uses CNN. There is an example on CIFAR-10 classification with various overfitting, good training, and performance boosting techniques [5]. ImageNet Classification with Deep Convolutional Networks is designed to category machine learning and image classification [6]. Many of techniques that use on model have references from [6]. They are the preprocessing techniques idea.

Consequently, some works focus on Classification of breast cancer histology. The latest version of histology image classification by using CNN, but histology image has its limitation which it is takes long time for the lab usage [7]. Reference [8] is the most cited paper that use MRI image for classification by using ANN, but MRI has a lot of radiation exposures that may harm to human health. However, mammogram image is the most suitable target for this work, since it is cheap than other treatment, and has very tiny radiation exposure from mammogram [8]. Therefore, many patients can have early checking if a faster mammograms image has been diagnosed. But mammogram also has its limitations for example some not clearly cancer cannot be scanned.

Some previously completed paper had used different types of neural network for classification mammogram image in breast cancer. Reference [9] is for the prediction of breast cancer by using artificial neural networks for classification and prediction [9]. The wavelet neural network is employed for breast cancer diagnosis [10]. Both neural networks are designed for general decision making purpose, so both of them need to setup many parameters than CNN which is designed for purpose recognize visual imagery. Same number of hidden layer, standard neural networks working on processing visual imagery need have $3x10^6$ parameters. But for CNN, it only needs around 600 parameters for processing visual imagery.

Reference [11] suggested a mammogram image detection using CNN. But the accuracy percentage is too low for a medical side solution which is around 60% for all classes detection, 75% for only masses class, and 100% for only calcification. Except only calcification argument, all argument and mass only argument can further be improved the accuracy to get a better performance [11].

## III. METHODOLOGY

### A. *Dataset*

In this experiment, mini-Mammographic Image Analysis Society (mini-MIAS) database of mammograms image has been used as experiments target [12], mini-MIAS is a database that reduces the size of the image by changing original image from 50 micron pixel edge to 200 micron pixel edge. There are 322 grayscale mammograms (161 pair of patient) with dimension of 1024 x1024 pixels.

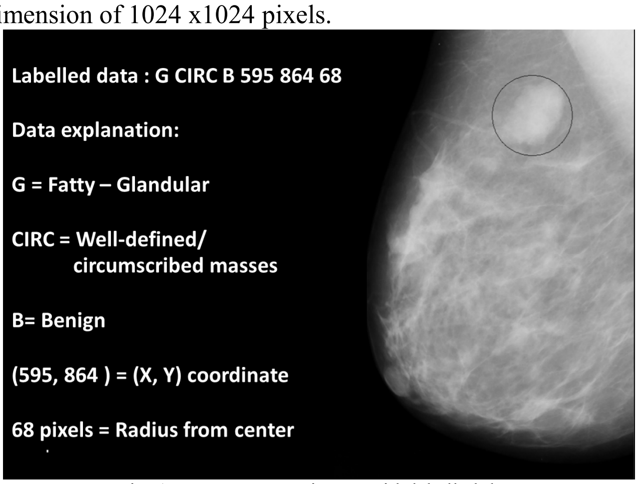


Fig. 1. Mammogram image with labelled data

Some important information has come with mini-MIAS dataset. Every data has labelled with character of background tissue and class of abnormality. Another information that given for abnormalities data is the severity of abnormality that present such as benign or malignant, x and y coordinates for centre of abnormality, and the abnormality radius measurement of pixels form. Fig. 1 is a mammogram image with labeled data explanation.

### B. *Image Preprocessing*

The raw data pixel size is too large. Huge segment of time is spent to adjust the input data for the classifier. Accordingly, most breast cancer tissue size is less than 20% percent from a 1024 x1024 pixel raw data, so it will affect the accuracy of the classifier performance and computation time. For a large pixels data as input of CNN classifier, it will spend a lot of computation time for every not necessary information or not important noise. At the same time, it also will affect the last result for the classifier.

In order to get only the important data, abnormality tissue is cropped and used in the CNN classifier. Fig. 2 shows examples of benign tissue. Fig. 3 shows example of malignant tissue. These images are cropped out by using mini-MIAS with the given X, Y coordinate and radius from the center point, after cropped resize it to 48 x 48 for uniform dimension as input of CNN classifier.

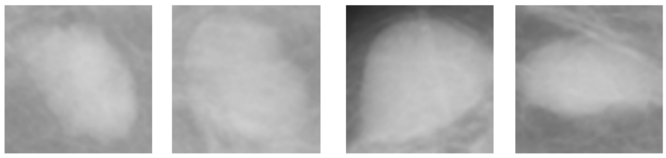

Fig. 2. Benign images before training

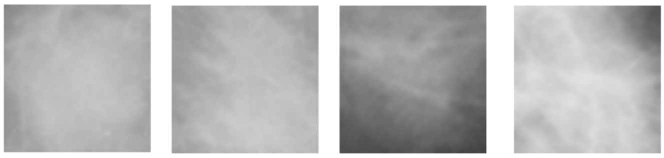

Fig. 3. Malignant tissues before training

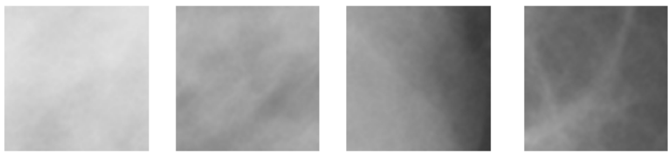

Fig. 4. Normal tissues before training

Fig. 4 shows the example of cropped normal tissue which is randomly cropped in order to make the CNN to classify smart which can identity normal patient also. Every image has been cropped at random spot at uniform dimension 48 pixel x 48 pixel.

To increase the accuracy of the model, we has subsampled the dataset by using image transformations. Rotation 90, 180, 270 degrees have been added into dataset. Horizontally reflected version for every rotation has also added to the dataset for train the system not only recognizes the fix position; but also can detect the abnormality smartly.

There are some abnormality tissues which are too close to limitation of mammograms such as examples shown in Fig. 5. When cropped out the image by giving labelled position and radius, it will has an blank area which is limitation area for mammogram, but the back blank may effect to the result of classifier. These types of data have been removed from the dataset for better accuracy.

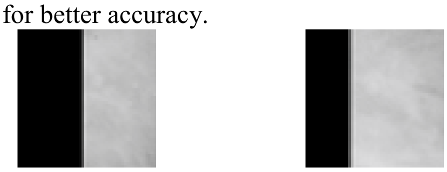

Fig. 5. Examples of bad train dataset

C. *TensorFlow*

TensorFlow library has been selected as model for the Machine Learning framework. It is a Google open source software library for Machine Intelligence [5]. It was made open source since November of 2015, before that it was only used by Google Brain team for machine intelligence or artificial intelligence research. Compare to other Machine Learning framework, TensorFlow is support Window system without install any other dependent. Most popular frames like caffe still not supporting Window system. These frameworks all designed for Linux system. However it still can be used on window. It also faces many warning and trouble when using it. TensorFlow API r1.3 has been used on BCDCNN. It has a new estimator which updated on March 2017, estimated the CNN by training data, evaluated data and predict the data without using dependent resource.

D. *Convolutional Neural Network*

Convolutional neural Network is made up of neurons that have learnable weights and biases. Each neuron receives some inputs. Then performs new a dot product and optionally follows it with a non-linearity. The whole network still expresses a single differentiable score function: from the raw image pixels on one end to class scores at the other.

Convolutional Neural Networks take advantage of the fact that the input consists of images and they constrain the architecture in a more sensible way. In particular, unlike a regular Neural Network, the layers of a CNN have neurons arranged in 3 dimensions: width, height, depth as shown in Fig. 6.

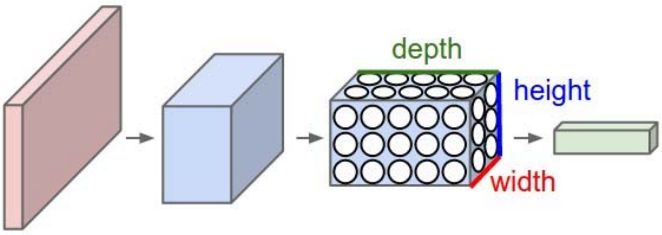


Fig. 6. A Convolutional Neural Network neuron arrangement [14]

A convolutional Neural Networks is a combination of many types of layers. As BCDCNN, method there are included input layer, 2 hidden layer, and output layer. Input layer is the image data that we input by pixel. In this model, grayscale mammograms as the input so it will have 48 x48 x1 input data for the CNN.

In hidden layer, there are many layers included such as convolutional layer, rectified linear unit (ReLU) layer, Pooling layer, Fully-connected (Dense) layer. Simple explanation for hidden layer is shown in Fig. 7.

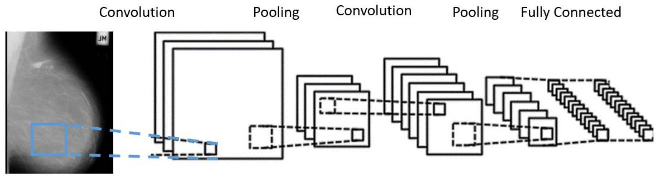


Fig. 7. Convolutional Neural Network process

Convolutional layers applied specified number of convolution filters to the image. For each subregion, the layer performs a set of mathematical operations to produce a single value in the output feature map as shown in Fig.7. Convolutional layers then typically apply a ReLU activation function to the output to introduce nonlinearities into the model. BCDCNN model has an input of 48 x 48 matrix and filter it into 32 features image by using kernel size of 5x5 filter with ReLU activation as Fig. 8.

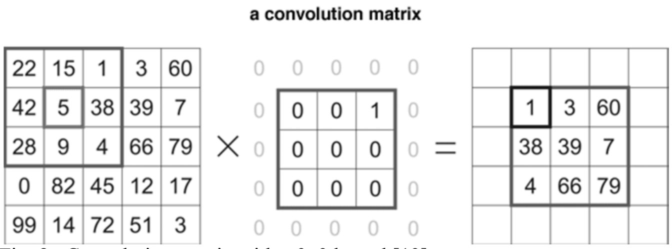


Fig. 8. Convolution matrix with a 3x3 kernel [13]

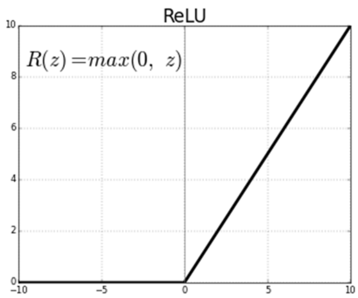


Fig. 9. ReLU activation function

Pooling layers downsamples the image spatially. A 2x2 filter max pooling example is shown in Fig. 10. A 2 x 2 filter is then applied on a matrix. The biggest number will be stored and the rest will be removed. It will then move 2 pixels to do another filter when we are given a stride value of 2. Purpose of this layer is to decrease the processing time.

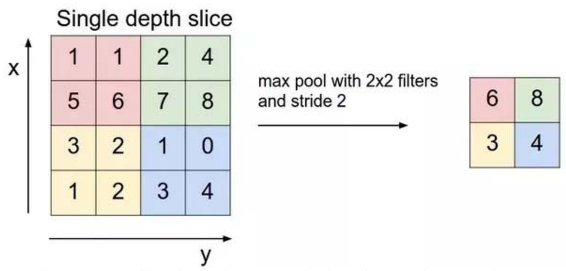


Fig. 10. Pooling layer in Convolutional neural network [14]

Same with other CNN model, BCDCNN uses back propagation for update weight for latest their closer value. When training the data, every time new image passes through the layer and a loss data will produce when comparing it out with expected output. By using this error, the model can update the network to improve it accuracy.

Last is Fully Connected Layers, This layer is a decision making layer. In this classifier, dense layer connected last hidden layer (7 * 7 * 64) into a 1024 node. Every node in layer will connect every node in the logits layer. In our model, the logits layer will have 3 types of possible output which is 0 for normal, 1 for benign, and 2 for malignant.

There are many parameters and methods to improve a CNN model, such as increase the data size, change on the training step, change on the learning rate, increase the pixel of the data for input layer, increase the hidden layer, and feature number. But model will be overfitting if getting too high learning rate and training step. There will make the model not flexible to be tested as a new input data.

## IV. RESULT AND DISCUSSION

As comparison a regular Neural Network that uses to process our model data has 48*48*1= 2304 weight parameters. For CNN model with a 32 feature map, it will only has 32 unique set weight parameters [14].

three types of version have been created. Version 1 is a Full Classification Example with ConvNet on Kaggle which classifies a batch of image into cat and dog [15]. It uses whole image as input. But the predicted outputs are wrong, when comparing without labeled data set for a medical side research. A true result is important than other component.

Version 2 is to follow the TensorFlow official guideline to develop a CNN model and scale down the whole image as the input data. However the true positive and true negative have been confirmed by given label to all input data when training and evaluation are conducted. The model will follow the label to train the classes. When evaluation is conducted, it will make a prediction on an image and compare it to given label. But once we use whole mammogram images as input, the size of breast cancer tissue is small than 20% from whole image so it will make the model more confusing the target to be classification. In this version we only get a very low accuracy.

Version 3 which is the current version. The model uses TensorFlow official guideline but the input data is the preprocessing data. The true positive and true negative have remained high due to given label to be tested and accuracy was increase to 0.827 which mean 82.7%. This model uses 48x48 as input, convolution layer with kernel size 5x5 filter, pooling layer with pool size 2x2 filter and strides of 2, learning rate with 0.003, training step with 20,000.

TABLE I. COMPARISON BETWEEN THREE VERSION

| Version | Version 1 | Version 2 | Version 3 |
|---|---|---|---|
| True Positive | 297 | 458 | 697 |
| True Negative | 597 | 916 | 1394 |
| False Positive | 1088 | 769 | 291 |
| False Negative | 544 | 385 | 146 |
| Calculations | | | |
| False Positive Rate | 64.57% | 45.64% | 17.27% |
| False Negative Rate | 64.68% | 45.68% | 17.32% |
| Sensitivity | 35.32% | 54.32% | 82.68% |
| Specificity | 35.43% | 54.36% | 82.73% |
| Accuracy | 38.45% | 54.35% | 82.71% |

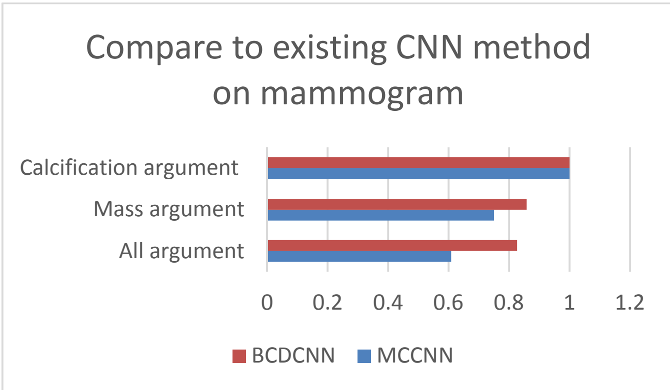


Fig. 11. Compare to existing CNN method on mammogram

Compared BCDCNN model with existing CNN Zhou et al paper, a comparison figure has shown in Fig. 11 [11]. The comparison is formed in all argument, mass argument and calcification argument. It is our target to improve the accuracy in all categories. Except calcification argument was 100% in both paper, mass and all argument have been increased from 0.75 to 0.8585 and 0.608974 to 0.8271 accuracy.

As the given dataset, over 60% is normal case. It may affect the balancing of the classifier to class the input in to 3 categories equally. To solve this problem. Both paper have classified for only calcification (0 normal, 80 Benign, 104 Malignant) and only mass (0 normal, 280 Benign, 144 Malignant). It is found that a mass only has around double of the data compare between benign and malignant, This may be the reason to cause the classifier confusing for BCDCNN model. Calcification only model has balance data between benign and malignant. This may be the reason to make classifier easier to form good model to classifier the input data.

Lastly in this experiment, we have limitation to get more data. More mammograms need to train a better model, but it is less open source research data. Besides that, my knowledge on breast cancer may cause limitation of BCDCNN model. All of the breast cancer location or accuracy follow the given labelled data, we are difficult to identity every tissue and cell from mammogram ourself. There are difficult to set a perfect setting of parameters. It will cause around a day for 1 run, but need to restart the training once changing the parameter. It is consumed much of time for the project. If we want to train faster, more hidden layer or more input pixel higher performance processer are required.

## V. CONCLUSION

The new version of breast cancer detection by using Convolutional Neural Network has been proposed and developed. This system classifies mammogram images into 3 categories: normal, benign and malignant with high rate than 80%. The system which can assist and help the doctor or specialist nurse to speed diagnosed the mammograms, to cover shortage of specialist or time handling diagnosed, every person can do a simple diagnosed though the system.

The method starts with preprocessing the mammograms to an image that can be easily recognize by a computer. The CNN model will find out different between every labelled data by using many types of feature getting from the image. After 20,000 times of comparison, it will come out a model that able to classification input image into closer possible output. The model only needs to train once. For the evaluation on predict images, it only takes few minutes to complete without times limit except any parameter that needs to change. Then, the model need to retrain for few day.

In conclusion, the breast cancer detection by using Convolutional Neural Network had been successfully developed and tested with 322 of mammogram images. This method provides a fast diagnosis time and high accuracy system.

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