

Deep learning method for Breast Cancer Classification

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Overview

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Background

- 523000 death and 2.4 million new patients / year
- 2nd major cause of cancer death after lung and bronchus cancer
- Most frequently diagnosis cancer among women in USA

- Early stage detection of breast cancer is curable
- Computer-aided diagnosis (CAD) system becoming popular
- ResNet deep learning approach for cancer detection is more reliable and effective

- `pyimagesearch.com`
- # of patients 279
- total 277523 patches of 50×50 pixels images
- file format `8863_idx5_x1001_y801_class1.png`

Dataset cont...

container	negative example (0)	positive example (1)	total data files	total files in %
train	143091	56725	199816	72 %
test	39748	15757	55505	20 %
validation	15899	6303	22202	8 %
total	198738	78785	277523	
dataset in %	71.71 %	28.39 %		

Method

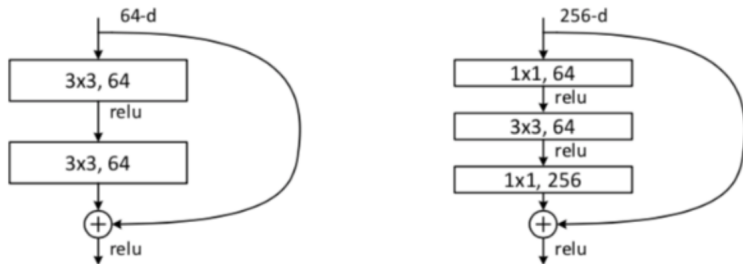


Figure: ResNet basic building block (left) & ResNet bottleneck building block (right)

Method cont...

layer name	output size	18-layer	34-layer	50-layer	101-layer	152-layer
conv1	112×112	7×7, 64, stride 2				
		3×3 max pool, stride 2				
conv2.x	56×56	$\begin{bmatrix} 3 \times 3, 64 \\ 3 \times 3, 64 \end{bmatrix} \times 2$	$\begin{bmatrix} 3 \times 3, 64 \\ 3 \times 3, 64 \end{bmatrix} \times 3$	$\begin{bmatrix} 1 \times 1, 64 \\ 3 \times 3, 64 \\ 1 \times 1, 256 \end{bmatrix} \times 3$	$\begin{bmatrix} 1 \times 1, 64 \\ 3 \times 3, 64 \\ 1 \times 1, 256 \end{bmatrix} \times 3$	$\begin{bmatrix} 1 \times 1, 64 \\ 3 \times 3, 64 \\ 1 \times 1, 256 \end{bmatrix} \times 3$
conv3.x	28×28	$\begin{bmatrix} 3 \times 3, 128 \\ 3 \times 3, 128 \end{bmatrix} \times 2$	$\begin{bmatrix} 3 \times 3, 128 \\ 3 \times 3, 128 \end{bmatrix} \times 4$	$\begin{bmatrix} 1 \times 1, 128 \\ 3 \times 3, 128 \\ 1 \times 1, 512 \end{bmatrix} \times 4$	$\begin{bmatrix} 1 \times 1, 128 \\ 3 \times 3, 128 \\ 1 \times 1, 512 \end{bmatrix} \times 4$	$\begin{bmatrix} 1 \times 1, 128 \\ 3 \times 3, 128 \\ 1 \times 1, 512 \end{bmatrix} \times 8$
conv4.x	14×14	$\begin{bmatrix} 3 \times 3, 256 \\ 3 \times 3, 256 \end{bmatrix} \times 2$	$\begin{bmatrix} 3 \times 3, 256 \\ 3 \times 3, 256 \end{bmatrix} \times 6$	$\begin{bmatrix} 1 \times 1, 256 \\ 3 \times 3, 256 \\ 1 \times 1, 1024 \end{bmatrix} \times 6$	$\begin{bmatrix} 1 \times 1, 256 \\ 3 \times 3, 256 \\ 1 \times 1, 1024 \end{bmatrix} \times 23$	$\begin{bmatrix} 1 \times 1, 256 \\ 3 \times 3, 256 \\ 1 \times 1, 1024 \end{bmatrix} \times 36$
conv5.x	7×7	$\begin{bmatrix} 3 \times 3, 512 \\ 3 \times 3, 512 \end{bmatrix} \times 2$	$\begin{bmatrix} 3 \times 3, 512 \\ 3 \times 3, 512 \end{bmatrix} \times 3$	$\begin{bmatrix} 1 \times 1, 512 \\ 3 \times 3, 512 \\ 1 \times 1, 2048 \end{bmatrix} \times 3$	$\begin{bmatrix} 1 \times 1, 512 \\ 3 \times 3, 512 \\ 1 \times 1, 2048 \end{bmatrix} \times 3$	$\begin{bmatrix} 1 \times 1, 512 \\ 3 \times 3, 512 \\ 1 \times 1, 2048 \end{bmatrix} \times 3$
	1×1	average pool, 1000-d fc, softmax				

Figure: ResNet Architecture

Method cont...

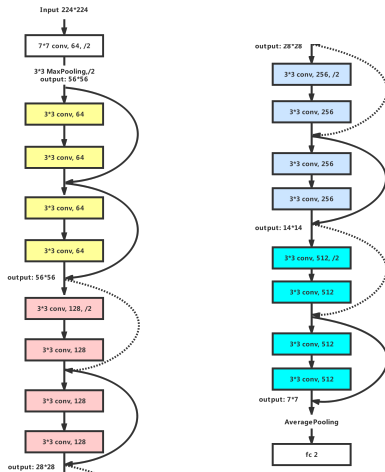


Figure: ResNet18

- ImageDataGenerator

Don't need to store data to memory every time

Mark the label of each image automatically

Image Augmentation to reduce the impact of minimization of dataset
(We take 15000 images for training and 2250 for validation because it takes 2 hours/epoch if we use the whole dataset)

- Parameters setting

batch size	lr	epochs	loss	optimizer	metrics
32	1e-5	150	categorical_crossentropy	Adam	accuracy

- Imbalance data issue

class_weight is calculated

class_weight is [1., 2.] is used

- Evaluation

Confusion matrix

True positives (TP)	False negative (FN)
False positive (FP)	True negatives (TN)

Formulas:

$$\text{accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$$

$$\text{sensitivity/recall (True positive rate)} = \frac{TP}{P} = \frac{TP}{TP+FN}$$

$$\text{specificity (True negative rate)} = \frac{TN}{N} = \frac{TN}{TN+FP}$$

$$\text{precision (Positive predictive value)} = \frac{TP}{TP+FP}$$

$$F_1 \text{ score} = \frac{2TP}{2TP+FP+FN}$$

Results

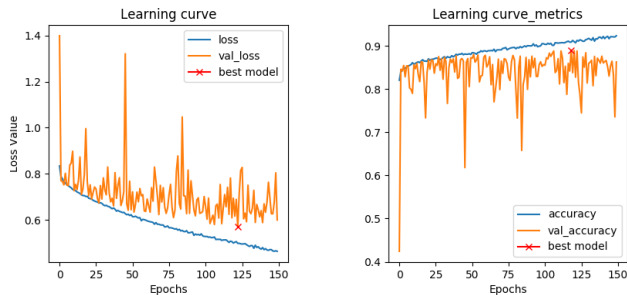


Figure: Learning curves of loss & accuracy

Results cont...

- Validation loss : 0.6163
Validation accuracy : 0.8785

- Confusion matrix:

TP: 36480	FN: 3239
FP: 3679	TN: 12107

- Results comparison

Parameters	our results	pyimagesearch.com
Accuracy	0.8629	0.8483
Recall	0.8875	0.8503
Precision	0.9182	N/A
Specificity	0.8011	0.8470
F_1	0.9026	N/A

Future work

- Apply the decay of learning rate in the Adam optimizer
- Implementation of deeper ResNet to train the dataset, like ResNet-34 or even ResNet-152
- Train on the whole dataset of more than 2,70,000 images
- To avoid overfitting we could play more with the parameters setting

QUESTIONS !



Bejnordi BE; Veta M; et al. *Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastase in Women eith Breast Cancer*, Dec 2017. 318(22): 2199-2210.



Syed JSG; Ahmed E; et al. *Breast Cancer Detection and Diagnosis Using Mammographic Data: Systematic Review*, Jul 2019. 21(7): e14464.