Non-Smokers' Lung Cancer Bio-Images Detection Using Deep Learning Approach

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Abstract
Lung disease can impair the respiratory system, is a foremost cause of human disease in the global space which impacts on its mortality rate. Mitigation in the detection of Histopathological bio-images (kind of a Lung cancer) is more powerful than detecting CT and X-Ray images. Screening the early Lung cancer stages in the image detection diagnosis approach would help in treatment on patients and doctor's decision strategy as well. Deep Learning (DL) techniques being emerged in the line of Medicare prediction, and its shown high level treatment efficiency and improving the care efficacy. Hence, here Convolutional Neural Networks (CNN), is an algorithm which exist sin DL domain and can be utilized in the classification of lung cancer images detection. Here, we investigated three lung cancer classes (Benign, Aden carcinomas, Squamous cell Carcinomas) – classification among Non-smokers by utilizing VGG-16-Data set. Data source is outsourced from Kaggle.com, which contains 15, 000 cases out of which 750 total cases are experimented via Jupiter Notebook-Python. Results delivered a very good achievable accuracy like 97.99% with ten iterations cycle.

Keywords:
Lung Cancer, Non-Communicable Diseases (NCD), Deep Learning, CNN, VGG-16, Histopathology Images, Non-Smokers.

1. Introduction

Cancer is that the uncontrollable organic process of abnormal cells within the organic structure, which might unfold to alternative body organs. If the Progressive part the cells starts sharply by range, size, and type primary tumors.Lung cancer digonasis[1] is split into 2 major varieties primarily based on microscopic anatomy, biological behaviour, prognosis and treatment. they're non-small cell carcinoma (NSCLC) and tiny cell carcinoma (SCLC). NSCLC is that the commonest cancer sort that accounts for eighty fifth and therefore the remaining V - J Day is SCLC. NSCLC is once more sub-divided into glandular carcinoma.

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1.2 Tumour

Tumours square measure typically divided into benign and malignant. Cancer cells don't continuously kind a compact growth. as an example, Leukaemia, could be a cancer within the blood-forming tissue wherever cancer cells flow into within the body and behave to some extent like healthy cells. Malignant implies that the neoplasm is created of cancer cells, and it will invade close tissues. Some willcer cells can come in the blood or body fluid nodes, wherever they'll unfold to alternative tissues among the body is named metastasis. whereas smoking continues to be far and away the most important reason behind cancer

1.3 Cancer

An abnormal growth of cells which tend to proliferate in an uncontrolled way and, in some cases, to metastasize (spread).Canceris not only disease, it is a group of more than 100 different and distinctive diseases.

The three main types are,

1. Lung Aden carcinoma **(Cancerous Tumor)**
2. Lung Benign Tissue **(Mass of Cells/large cell carcinoma)**
3. Lung Squamous Cell Carcinoma **(Common form of Cancer).**

1.4 Stages of Lung Cancer

1.4.1 Small Cell Lung Cancer Stages (SCLC)

Limited stage: In this form, a small cell lung cancer is limited to one side of the chest, typically in the lungs and lymph nodes. About one in three people with small cell lung cancer can have limited stage cancer upon the first diagnosis.

Extensive stage: Nodes on the other side of the chest or to other body parts. About two in three people with small cell

lung cancer can have extensive stage cancer upon first diagnosis.

1.4.2 Non-Small Cell Lung Cancer Stages (NSCLC)

Occult (hidden) stage: In this stage, cancer cells appear in a sputum cytology exam or other test, though no tumor location can be found.

2. Smokers Vs Non-Smokers

2.1 Smokers

Smokers can developall types oflung cancers, although the association is stronger for small celllung cancerand squamous cell carcinoma, whereas never-smokersare more likely to develop a non small cell lung cancercalledLungAdenocarcinoma.

2.2 Non-Smokers

Non-smokers/Formersmokes are adults who have smokedat least 100 cigarettes in his or her lifetime. Neversmokers are adults who have neversmoked, or who havesmokedless than 100 cigarettes in his or her lifetime.

2.3 Non-Smokers affected by Cancer

Tobaccosmokein enclosed spaces is breathed in by everyone, exposingsmokersandnonsmokersalike to its harmful effects. In adults, second-handsmokecauses serious cardiovascular and respiratory diseases, including coronary heart disease and lung cancer.

3. Literature Review

Ahmed Elnakib**[3]**, Hanan M. Amer using CAD and proposed computed tomography (LDCT) images with deep learning featuresare thenextractedbyinvestigating different deep learning architectures,including Alex, VGG16, and VGG19 networks using a genetic algorithm(GA)is trained to select SVM classifier,achieves the best detectionaccuracy of 96.25%, sensitivity of 97.5%, and specificity of 95%.

StvikGarg and SomyaGarg**[4]**If a histologist is under-prepared, deep learning is being valued in the analysis of Medical Imaging. This paper intends to utilize and alter the current pre-trained CNN-based model to identify lung and colon cancer utilizing histopathological images with better augmentation techniques. The model performances are assessed on precision, recall, f1score, accuracy, and auroc score. The results exhibit that all eight models accomplished noteworthy results ranging from 96% to 100% accuracy.

Zhuo Liu, ChenhuiYa, et.al., focus on the potential of the deep reinforcement learning for lung cancer detection **[5]** as many people are suffering from the lung tumor and about 1.8 million patients died from lung cancer in 2018, which is expected to promote the evolution of smart medicine with medical Internet of Things.

KhushbooMunir,Hassan Elahiet,al., Artificial intelligence and cancer diagnosis are gaining attention as a way to define better diagnostic tools. In particular, deep neural networks **[6]** can be successfully used for intelligent image analysis.It describes many different techniques for different cancers.

Bijaya Kumar Hatuwaand Himal Chand Thapa,using the CNN model **[7]** training and validation accuracy of 96.11 and 97.2 percentage are obtained. The precision, f1-socre, recall were calculated, and a confusion matrix plot was drawn to measure the model performance.

4. Implementation

4.1 Jupiter Notebook

The Jupyter Notebook is an open-source web application that allows data scientists to create and share documents that integrate live code, equations, computational output, visualizations, and other multimedia resources, along with explanatory text in a single document.Jupyter Notebooks are powerful, versatile, shareable and provide the ability to perform data visualization in the same environment. Jupyter Notebooks allow data scientists to create and share their documents, from codes to full blown reports.

4.2 Python

It is aninterpretedhigh-levelgeneral-purpose programming language. Its design philosophy emphasizescode readabilitywith its use ofsignificant indentation. Itsobject-orientedapproach aim to helpprogrammersto write a clear, logical code for small and large-scale application projects. It is a computer programming language often used to build websites and software, automate tasks, and conduct data analysis. Python is a general purpose language, meaning it can be used to create a variety of different programs and isn't specialized for any specific problems.

4.3 Kaggle Dataset Collection

The image dataset (Kaggle) contains 15,000 histopathological images with three classes. All images are 768 x 768 pixels in size and are in jpeg file format. The images were generated from an original sample of HIPAA (Health Insurance Portability and Accountability Act) compliant and validated sources, consisting of 750 total images of lung tissue (250 benign lung tissue, 250 lung adenocarcinomas, and 250 lung squamous cell carcinomas) to 15,000 using the Augmentor package.

There are three classes in the dataset **[8]&[9]**, each with 5,000 images area like,

1. Lung adenocarcinoma **(class-1)**
2. Lung benign tissue **(class-2)**
3. Lung squamous cell carcinoma **(class-3).**

5. Proposed Work-Methodology

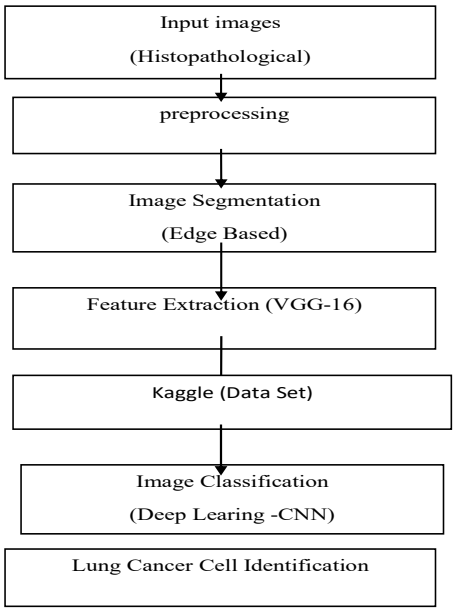

Figure 1: Process Flow Diagram

To classify the carcinoma pictures, the informationset is obtained from LC25000 respiratory organ and colon histopathological image dataset that is already increased data having 5000 pictures in every category of carcinoma image set comprising 3 categories. This dataset is pre-processed victimization python tools and options area unit extracted by CNN techniques, later the model is made and evaluated. numerous CNN techniques area unit accustomed compare and classify the photographs.

5.1 Histopathological images

Histopathological pictures Histopathology is that the study of the signs of the malady victimization the microscopic examination of a diagnostic assay or surgical specimen that's processed and stuck onto glass slides. to ascertain completely different parts of the tissue beneath a magnifier, the sections area unit unreal with one or additional stains. Histopathology is that the designation and study of diseases of the tissues, and involves examining tissues and/or cells beneath a magnifier. Histopathologists area unit to blame for creating tissue diagnoses and serving to clinicians manage a patient's care.

5.2 Preprocessing

Preprocessing Image preprocessing area unit the steps taken to format pictures before they're employed by model coaching and reasoning. This includes, however isn't restricted to, resizing, orienting, and color corrections. ... Thus, a metamorphosis that would be associate augmentation in some things could best be a preprocessing step in others.

5.3 Segmentation

In Digital Image Processing and Computer Vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as image objects). Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in the images. Segmentation is an important stage of the image recognition system, because it extracts the objects of our interest, for further processing such as description or recognition. Segmentation techniques are used to isolate the desired object from the image in order to perform analysis of the object. Segmentation is the process of determining the boundaries and areas of objects in images.

5.3.1 The primary types of image segmentation techniques

1. Thresholding Segmentation
2. Region-Based Segmentation
3. Edge based Segmentation and
4. Clustering-Based Segmentation

5.3.1.1 Thresholding Segmentation

The process of thresholding involves, comparing each pixel value of the image (pixel intensity) to a specified threshold. This divides all the pixels of the input image into 2 groups: Pixels having intensity value lower than threshold. Pixels having intensity value greater than threshold.

5.3.1.2 Region-Based Segmentation

The region-based segmentation method looks for similarities between adjacent pixels. That is, pixels that possess similar attributes are grouped into unique regions. ... Regions are grown by grouping adjacent pixels whose properties, such as intensity, differ by less than some specified amount.

5.3.1.3 Edge based Segmentation

In edge-based segmentation, an edge filter is applied to the image, pixels are classified as edge or non-edge depending on the filter output, and pixels which are not separated by an edge are allocated to the same category.

5.3.1.4 Clustering-Based Segmentation

Clustering algorithms are used to group closer the data points that are more similar to each other, from other group data points.If we can cluster these points we can distinguish each object from one another right. That's how the cluster-based segmentation works.

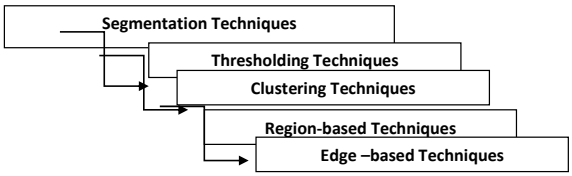

Figure 2: Image segmentation Techniques

5.4 Feature Extraction

Feature extraction could be aa part of the spatiality reduction method, in which, associate initial set of the information is split and reduced to additional manageable teams. thus after you wish to method it'll be easier. the foremost necessary characteristic of those massive knowledge sets is that they need an outsized variety of variables.Feature extraction is employed to decrease the model quality wherever necessary options square measure recognized from the photographs. For the information extraction from pictures, not all the options offer attention-grabbing rules for the matter. this can be the main step wherever the model performance and effectiveness square measure dependent. To extract such options as color, texture, and structure, image-processing techniques square measure used. this will be achieved by localizing the extraction to little regions and guaranteeing to capture all areas of the image.

5.5 Image Classification

Image classification [13]&[14]is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. The categorization law can be devised using one or more spectral or textural characteristics. Two general methods of classification are 'supervised' and 'unsupervised'. CNNs are used for image classification and recognition because of its high accuracy. The CNN follows a hierarchical model which works on building a network, like a funnel, and finally gives out a fully-connected layer where all the neurons are connected to each other and the output is processed.

5. Deep Learning

Deep Learning refers to the quantity of layers through that the information is remodeled. Deep Learning could be a kind of Machine Learning, that could be a set of computer science. Machine Learning is regarding computers having the ability to assume and act with less human intervention; it's regarding computers learning to assume victimization structures sculptured on the human brain.Deep Learning is termed Deep due to the quantity of extra “Layers” we have a tendency to boost learn from the information. A Layer is Associate in Nursing intermediate row of alleged “Neurons”.Deep Learning could be a category of Machine Learning Algorithms that uses multiple layers to more and more extract higher-level options from the raw input. for instance, in image process, lower layers could establish edges, whereas higher layers could establish the ideas relevant to a person's like digits or letters or faces or cancer tissues [15]&[16].

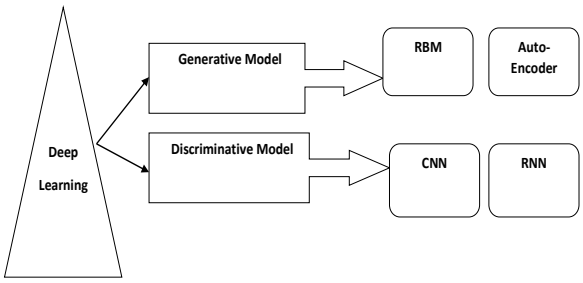

Figure 3: Methods on Deep Learning Model

6.1 Generative Model

Generative Model A generative model includes the distribution of the information itself , Deep Generative Models (DGM) square measure neural networks with several hidden layers trained to approximate difficult, high-dimensional chance distributions victimisation samples. once trained with success, we are able to use the DGM to estimate the chance of every observation and to form new samples from the underlying distribution.

a) Restricted Boltzmann Machine(RBM)

a) Restricted Ludwig Boltzmann Machine (RBM) A RBM could be a generative random artificial neural network that may learn a chance distribution over its set of inputs. Restricted Ludwig Boltzmann Machines can even be employed in deep learning networks. RBMs were fancied by Geoffrey Hinton and may be used for spatial property reduction, classification, regression, cooperative filtering, feature learning, and topic modelling. RBMs square measure a special category of Ludwig Boltzmann Machines and that they square measure restricted in terms of the connections between the visible and also the hidden units.

b) Auto-endoder

Auto-encoder could be a variety of neural network that may be wont to learn a compressed illustration of data. associate degree Auto-encoder consists of associate degree encoder and a decoder sub-models. The encoder compresses the input and also the decoder makes an attempt to recreate the input from the compressed version provided by the encoder.

6.2 Discriminative Models

Discriminative Models The discriminative model refers to a category of models utilized in applied math Classification, chiefly used for supervised machine learning. These kinds of models also are called conditional models since they learn the boundaries between categories or labels in an exceedingly dataset.

Convolutional Neural Network (CNN)

a) Convolutional Neural Network (CNN) A convolution is that the straightforward application of a filter to Associate in Nursing input that leads to Associate in Nursing activation like CNN apply a filter to Associate in Nursing input to make a feature map that summarizes the presence of detected options within the input.The 2 main approaches to image segmentation area unit supported convolutional neural networks (CNN) and superpixels. Superpixel is Associate in Nursing approach that divides a picture into regions (called superpixels) with similar properties, like color, texture, and brightness.Mask R-CNN, or Mask RCNN, may be a Convolutional Neural Network (CNN) and progressive in terms of image segmentation and instance segmentation.

Model Built

```
base_model = VGG16(weights='imagenet', include_top=False)
x = base_model.output
x = GlobalAveragePooling2D(name='avg_pool')(x)
x = Dropout(0.2)(x)
pred = Dense(3, activation='softmax')(x) //Activation Function//
model = Model(inputs=base_model.input, outputs=pred)
model.summary()
Model: "model_1"
```

Figure 4 :Softmax function used CNN model

```
PSEUDOCODE OF CONVOLUTIONAL LAYER
1 for (l = 0;l<L ;l ++){
2     for (m = 0;m<M ;m ++){
3       for (n = 0;n<N ;n ++){
4           sum = bias[l];
5           for (k = 0;k<K ;k ++){
6                 for (s1 = 0;s1 <S1;s1 ++){
7                       for (s2 = 0;s2 <S2;s2 ++){
8                 sum+=weight[k][l][s1][s2] × input [k][m + s1][n + s2];
9           }}}
10      output [l][m][n] = activation_func(sum);
11 }}}
```

Figure 5: Pseudo Code of CNN

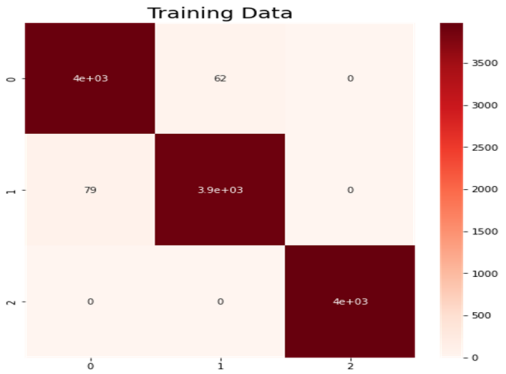

Figure 6: Training Data Plotting the Model Predicting the Loss

```
model.load_weights('E:\Others\BMF\LungCancer_Analysis\LungCancerData1\modelWeights10.h5')
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Loss','Val_Loss'], loc='upper left')
plt.show()
```

Plotting the Accuracy

```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Acc','Val Acc'], loc='lower left')
plt.show()
```

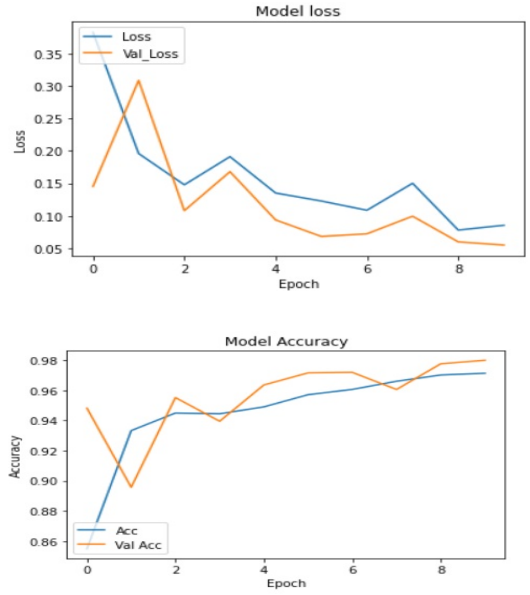

Figure 7: Prediction and Accuracy

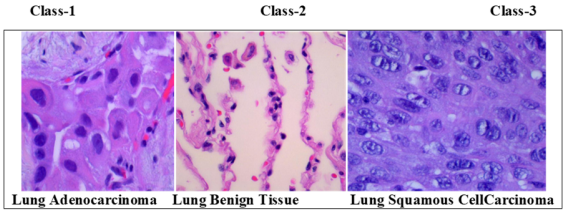

Figure 8: Prediction of Sample images of three classes present in the dataset.

8. Evaluation Metrics

In order to evaluate the performance of the model the following metrics are measured:

Accuracy: Over the total number of data instances accuracy represents the correctly classifieddata represents the formula to calculate accuracy. However, accuracy alone maynot be a good measure to decide the performance of the model.

Precision: This is used to measure the positive predictive observations. It represents the correctly predicted positive observations of total predicted positive observation is the formula to calculate the precision. High precision relates to a low false-positive rate.

Recall (Sensitivity): Recall represents the correctly predicted positive observations of total actual positive observations. The formula to calculate recall is given. It is also known as sensitivity or true positive rate.

F1 score: Ideally, a good evaluation should consider both precisions and recall to seek balance. A weighted average of precision and recall is the F1 score. In the formula to calculate the F1 score. For uneven class distribution, the F1 score is more useful to evaluate the model.

$$\textbf{\textit{Accuracy}}=(TP+TN)/((TP+FP+FN+TN)) \quad (1)$$

$$\textbf{\textit{Precision}}=TP/((TP+FP)) \quad (2)$$

$$\textbf{\textit{Recall}}=TP/((TP+FN)) \quad (3)$$

F1-Score =2X Recall X Precision / Recall + Precision

Figure 9: Evaluation Metrics

8.1 Statistics of Overall Data

Training Data	Training Label	Validation Data	Validation Label
12000	12000	2990	2990

9. Results and Analysis

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	(None, None, None, 3)	0
block1_conv1 (Conv2D)	(None, None, None, 64)	1792
block1_conv2 (Conv2D)	(None, None, None, 64)	36928
block1_pool (MaxPooling2D)	(None, None, None, 64)	0
block2_conv1 (Conv2D)	(None, None, None, 128)	73856
block2_conv2 (Conv2D)	(None, None, None, 128)	147584
block2_pool (MaxPooling2D)	(None, None, None, 128)	0
block3_conv1 (Conv2D)	(None, None, None, 256)	295168
block3_conv2 (Conv2D)	(None, None, None, 256)	590080
block3_conv3 (Conv2D)	(None, None, None, 256)	590080
block3_pool (MaxPooling2D)	(None, None, None, 256)	0
block4_conv1 (Conv2D)	(None, None, None, 512)	1180160
block4_conv2 (Conv2D)	(None, None, None, 512)	2359808
block4_conv3 (Conv2D)	(None, None, None, 512)	2359808
block4_pool (MaxPooling2D)	(None, None, None, 512)	0
block5_conv1 (Conv2D)	(None, None, None, 512)	2359808
block5_conv2 (Conv2D)	(None, None, None, 512)	2359808
block5_conv3 (Conv2D)	(None, None, None, 512)	2359808
block5_pool (MaxPooling2D)	(None, None, None, 512)	0
avg_pool (GlobalAveragePooli	(None, 512)	0
dropout_1 (Dropout)	(None, 512)	0
dense_1 (Dense)	(None, 3)	1539

Total parameters: 14,716,227
Trainable parameters: 14,716,227
Non-trainable parameters: 0

Table 1: Different Categories of Cancer Prediction

Category	Precision	Recall	F1- score
Adenocarcinoma	**0.95**	**0.97**	**0.96**
Benign Tissue	**1.00**	**1.00**	**1.00**
Squamous Cell Carcinoma	**0.97**	**0.95**	**0.96**

Thus, by this approach the output is obtained using deep learning, which predicts and classification of the histopathological images. Finally, the overall accuracy of 10 images obtained is about **97.99%.** This is obtained at an accurate ratio as shown below.

Table 2: Prediction Accuracy of every image

Dataset ImageNumber	Accuracy of each Image
1	0.9482
2	0.8957
3	0.9552
4	0.9395
5	0.9635
6	0.9716
7	0.9719
8	0.9605
9	0.9776
10	0.9799
Overall accuracy	**97.99%**

10. Conclusion

This research work provides a lung most cancers prediction which uses histopathological images. A Convolutional Neural Network (CNN) changed into carried out to categorise an images of 3 exceptional classes benign, Adenocarcinoma, and squamous mobileular carcinoma. The version changed into capable of attain 97.99% of prediction and validation accuracy. The precision, F1- Score, remember had been calculated, and a confusion matrix plot changed into attracted to degree the version performance. Hence, Deep Learning is used for the classification of lung images for the detection of cancer.

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