

# Detecting Lung Cancer from PET Images Using CNN

Sanyogita Bobade <sup>1</sup>, Aditi Deshmukh <sup>2</sup>, Abhinav Deshpande <sup>3</sup>, Pratik Deshpande <sup>4</sup>, Shalini Wankhade<sup>5</sup>

U.G. Student, Department of Computer Engineering, SAE Engineering College, Pune, Maharashtra, India<sup>1</sup>

U.G. Student, Department of Computer Engineering, SAE Engineering College, Pune, Maharashtra, India<sup>2</sup>

U.G. Student, Department of Computer Engineering, SAE Engineering College, Pune, Maharashtra, India<sup>3</sup>

U.G. Student, Department of Computer Engineering, SAE Engineering College, Pune, Maharashtra, India<sup>4</sup>

M.Tech, Assistant Professor, Department of Computer Engineering, SAE Engineering College, Pune,  
Maharashtra, India<sup>5</sup>

**ABSTRACT:** The mortality rate due to lung cancer is increasing rapidly day by day. The major reason behind this increasing mortality rate is not being able to detect the lung cancer at an early stage. Even due to advancement in technology, the number of radiologists is limited and they are being overworked. Various methods which are based on technologies like deep learning and CNN (Convolutional Neural Network) have been developed to automatically detect lung cancer through medical images. This paper presents a CNN system which is used for analysing the patient imagery captured by the PET (Positron Emission Tomography) scans, using the knowledge from both nuclear medicine and neural network. In this paper, why particularly CNN along with the fundamental basic knowledge of CNN is provided. Also, the layers which helps CNN in identifying the lung cancer are explained with the reasons for its suitability in medical image analysis. Along with that, a brief description of medical image dataset used, as well as the working environment required for managing lung nodule analysis using CNN, is specified. Due to advancement in the technology of CNN, it has become possible to diagnose the possibility of lung cancer and hence, begin with the medications earlier, thus helping to reduce the mortality rate.

**KEYWORDS:** Lung cancer, Deep Learning, Artificial Neural Network, CNN, PET

## I. INTRODUCTION

Cancer can be defined as the growth of abnormal cells which divide uncontrollably and destroy the body tissues. Major types of death causing cancers includes lung cancer, breast cancer, brain cancer, mouth cancer, blood cancer, etc. Lung cancer basically begins in the lungs and may either spread to the lymph nodes or other organs in the body. It is caused due to major reasons like smoking, exposure to toxin and sometimes even due to family hereditary. Two broadly classified types of lung cancer are:

i. Small Cell Lung Cancer (SCLC):

For every count of 100 lung cancers diagnosed, 12 are of this type. It is usually caused due to smoking. This type of cancer tends to spread early, affecting the other organs.

ii. Non-small Cell Lung Cancer (NSCLC):

For every count of 100 lung cancers diagnosed, 87 are of this type. This type of cancer can further be divided into three common types. They are grouped together because they all behave in a similar fashion and also respond in similar way. The three types are:

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

a. Adenocarcinoma:

It accounts for about 40% of all the lung cancers. It starts in glandular cells, which secrete substances like mucus and develops in the alveoli. It is usually located mostly along the outer edges of the lung.

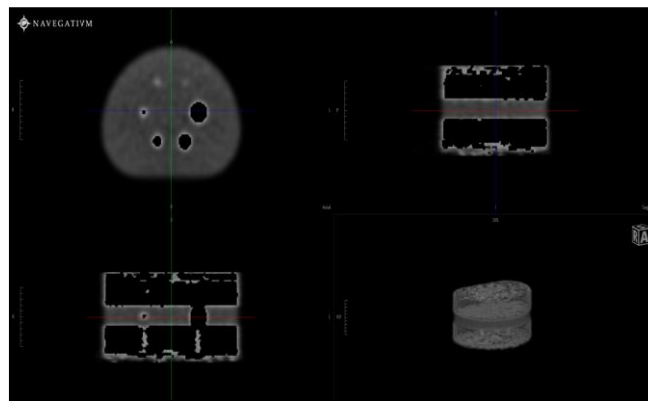


Fig 1. PET scan image rendered by using NAVIGATVM application retrieved from RIDER Lung PET - CT dataset

b. Squamous:

It accounts for about 30% of all the lung cancers. This type is developed in flat cells, which usually cover the surface of the airways. It tends to grow near the center of the lung.

c. Large cell cancer:

These type of cancer cells appear large and round under the microscope. It can be found anywhere in the lung, although it is more often found in the periphery.

The rapid advancement in CT (Computed Tomography) and PET scan techniques have been remarkable. But ultimately it has led to the production of image data in huge numbers. This increases the workload on the radiologists which can be prone to erroneous diagnosis. This ultimately affects the end result. Recently, Convolutional Neural Network has been utilized remarkably in the field of medical, for diagnosis and analysis of medical image datasets. Appreciable reviews have been published on the working of CNN in applications like analysis of lungs, brain, prostate and breast cancers [1][2][3].

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

## II. RELATED WORK

Year	Author	Model	Dataset	Key Points
2019	Patrice et al. [15]	CNN	LIDC/IDRI, LUNA16, NLST, KDSB and ELCAP	A survey on detection and classification of pulmonary nodules using Convolutional Neural Networks
2019	Hongtao et al. [13]	Deep CNN	LUNA16	Automated pulmonary nodule detection in CT images using deep convolutional neural networks
2018	Ali et al. [16]	3D CNN	LUNA16	Used Reinforcement Learning to detect pulmonary nodules
2018	Liu et al. [17]	2D CNN	LIDC/IDRI and ELCAP	2D CNNs are trained with dataset of CT images to accurately identify nodule types
2018	Qin et al. [18]	3D U-Net and 3D DenseNet	LUNA16	Regional Proposal Network is used for nodule candidate generation
2017	Sindhu et al. [20]	YOLO (You Only Look Once)	LIDC/IDRI	You Only Look Once (YOLO) determines the location of the object in the image
2016	Setio et al. [12]	CNN	LIDC/IDRI	False positive reduction using multi-view Convolutional Networks

## III. PET SCAN

PET stands for Positron Emission Tomography. It is a nuclear medicine functional imaging technique that is used to observe metabolic processes in the body, as an aid to diagnose the disease. PET scan detects radiations that are emitted by a radiotracer. A radiotracer is injected into the human body, where it travels to the cells that use glucose for energy consumption. The more energy a group of cells need, the more radiotracer will build up in that specific region. This will show up on the reconstructed image. The cells will show up as “hot spots” or “cold spots”. Active areas are bright in a PET scan, which are known as “hot spots” where as the cells that need less energy will not be bright and are known as “cold spots”. Compared to the normal cells, the cancer cells are very active in glucose consumption and that is the reason a radiotracer made with glucose will light up the areas of cancer. It is excellent at analyzing the abnormal processes. It helps in diagnosing lung cancer at earlier stages. It is highly accurate in determining the cancerous mass, if present. Early changes in cell detection is remarkable than Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

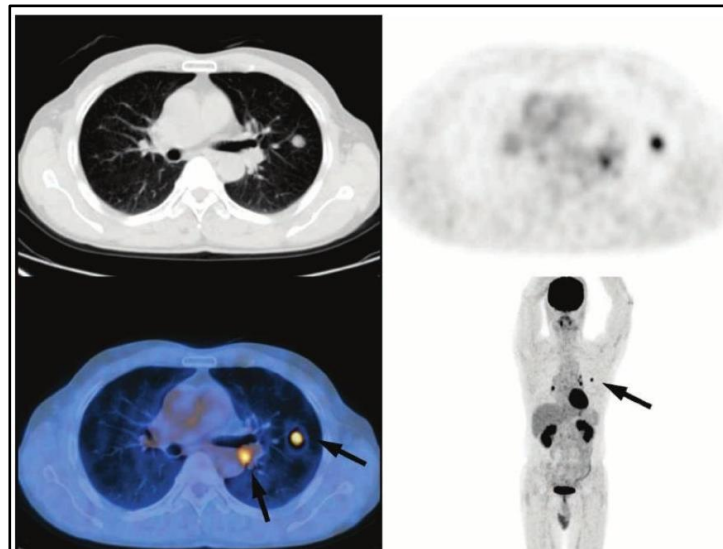


Fig.2. PET scan image

## IV. DATASETS

As the implementation of CNNs require a huge setup of parameters consisting of specific hardware and software requirements. The datasets used for training and testing of the proposed system are:

### A) Datasets of lung cancer PET images:

The datasets of lung cancer PET images which are generally used are:

#### 1. RIDER Lung PET-CT dataset:

RIDER stands for Reference Image Database to Evaluate therapy Response. The dataset includes images from PET/CT and other modalities such as CT and magnetic resonance imaging (MRI) along with relevant metadata and clinical outcomes. The main purpose of the RIDER database is to develop a public resource of temporally sequential images. The images were acquired during the diagnosis of various lung cancer drug and radiation therapy tests across various clinical centers. Hence, analysis of software tools may be optimized and updated and will be helpful for getting the point of references. These references were marked earlier during the training of the system to use them in future tests. Patient's images acquired under situations of certain no change in tumor size will be provided and it will also provide biological information if the "true" change is known in tumor size and more such related information will be provided and will play a key role in evaluation of software tool performance. The RIDER database highlights the importance of creating standard methodology for similar software tools to reduce sources of uncertainty in important clinical decisions such as whether a specific tumor is responding to therapy or not [4].

#### 2. NSCLC Radio genomics dataset:

NSCLC stands for Non-Small Cell Lung Cancer. It is a unique radio genomic dataset from a NSCLC companion of 211 subjects. The dataset comprises of Computed Tomography (CT), Positron Emission Tomography (PET) images. Also, dataset consists of semantic annotations of the tumors as observed on the medical images using a controlled vocabulary. The segmentation maps of tumors in the CT scans, and quantitative values are also obtained from the PET/CT scans. Imaging data are also paired with gene mutation, RNA sequencing data from samples of

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

surgically excised tumor tissue, and clinical data, including survival outcomes. This dataset was created to make the discovery of the underlying relationship between genomic and medical image features easy, as well as the development and evaluation of prognostic medical image biomarkers [5].

## B) Datasets used for the proposed system:

- a. RIDER: The described dataset is used for training the system for identifying the presence of cancer. The identified nodule is classified into two classes:
  - i. Benign: A benign tumor is a tumor that does not invade its surrounding tissue or spread around the body. Hence, it can be stated that if the tumor is found to be benign then it is classified as non-cancerous.
  - ii. Malignant: A malignant tumor is a tumor that may invade its surrounding tissue or spread around the body. Hence, it can be stated that if the tumor is found to be malignant then it is classified as cancerous.
- b. Live Dataset: The proposed dataset is the actual PET image dataset of the patients of a multispecialty hospital which has been diagnosed for lung cancer. This dataset is used as testing data for the system, hence, classifying the patients' data into benign and malignant.

## V. CNN

### A. What is Pattern Recognition?

Pattern is found everywhere. A pattern is a repeated design. Pattern recognition is closely related to artificial intelligence and machine learning. Basically, pattern recognition is a process of recognizing patterns using machine learning. It classifies the data based on prior and learnt knowledge which includes identifying familiar patterns as well as images, from different angles. It also includes converting raw data to machine useful data. Pattern recognition provides quite remarkable accuracy as per the researches [9]. The Convolutional Neural Network model is popular among other pattern recognition models like multi-layer perceptron and radiomics. The CNN model uses pattern recognition for automatic discovery of regularities in data (patterns) through the use of computer algorithms. It uses data characterization algorithms to extract features from radiographic medical images. This is how the CNN model can be used for lung nodule detection in the PET images. Thus, using pattern recognition, CNN tries to assign the given input to one of the predefined classes. Also, CNN gives promising outcomes, high level image representations and thus, provides higher accuracy.

### B. What is neural network?

Neuron is the basic building block of the nervous system. The key difference between neurons and other cells is that the neurons are responsible for transmitting information throughout the body. The information transmission occurs through both chemical and electric forms. There are particularly three types of neurons found in the human body:

1. Sensory Neurons: These neurons are triggered by physical and chemical inputs from the environment, based on the sensed intensity.
2. Motor Neurons: These play a major role in the voluntary and involuntary movements of the body.
3. Inter Neurons: These are neural intermediaries that pass signals from sensory neurons to other inter neurons or from inter neurons to the motor neurons.

A single neuron consists of 3 essential parts that control its functioning. These include cell body, axon and dendrites. Their functionality is:

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

1. Cell body:  
The cell body, also known as 'soma' (neuron's core), carries genetic information and has the action potential to drive the activities. It contains the nucleus of neuron.
2. Axon:  
It is a long tail-like structure which joins the cell body and its terminals. These contain substances that help conduct electricity for information transmission.
3. Dendrites:  
These are fibrous roots that branch out from the cell body and are used to receive and process signals from the axons of other neurons. Neurons can have more than one set of dendrites. These are then called as dendritic tree.

How do the neurons transmit the messages? This can be answered as - If a neuron's cell body receives a large number of inputs from the other neurons, these signals add up until they exceed a particular threshold. As soon as this threshold is exceeded, the neuron is triggered to transmit an impulse along its axon.

Each neuron is connected to 1000 other neurons creating a complex network. This biological structure of neurons, i.e. the neural network, is implemented artificially in the convolutional neural network.

## C. CNN Overview:

Convolutional Neural Network (CNN or ConvNet) is a class of deep neural networks, which is mostly applied in analyzing visual imagery [6]. Deep Neural Networks are becoming more and more popular as they can be easily applied in image classification as well as image pattern recognition. CNNs were one of the first deep learning models biologically inspired by the visual cortex of mammals [7][8][9]. It is inspired by the neurons present in the mammals, that creates a complex network, used for performing complex day-to-day operations, conveniently. ConvNets are very similar to normal neural networks (a collection of neurons arranged as an acyclic graph). CNNs are a specialized kind of neural network for processing data that has a grid-like topology [10]. The design of CNN basically follows vision processing in the living organisms. From producing a system for recognizing hand-written Zip-Code numbers [19] using back-propagation to GPU implementations of CNN, the ConvNets went through a great evolution in the field of deep learning and has effectively replaced traditional image processing techniques.

ConvNets are simply the neural networks that use convolution in place of general matrix multiplication in at least one of its layers. Generally, convolutional neural network consists of a stack of convolutional layers that are learned according to the aim of the problem, by extracting useful information or patterns from the given input. CNN consists of a number of hidden layers including an input layer and an output layer. ConvNets differ in its architecture as here, the hidden layer neuron is connected only to a subset of neurons in the previous layer. Because of this sparse connectivity it is capable of learning features implicitly [11]. On the basis of the number of hidden layers, a convolutional neural network can be differentiated into deep or a shallow network. A deep neural network (DNN) has multiple layers (hidden layers) between the input and output layers. The network moves through the layers, calculating the probability of each output. DNNs are typically feed forward neural networks in which the data moves from input layer to the output layer, without looping back. However, shallow neural networks consist of only 1 or 2 hidden layers.

Training a ConvNet is the process of optimizing different parameters such as kernels (weight matrix) for minimizing the difference between output and the ground truth labels. For this purpose, the system must first be trained using a labeled dataset, also called as a training dataset. The algorithm used for training purpose includes

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

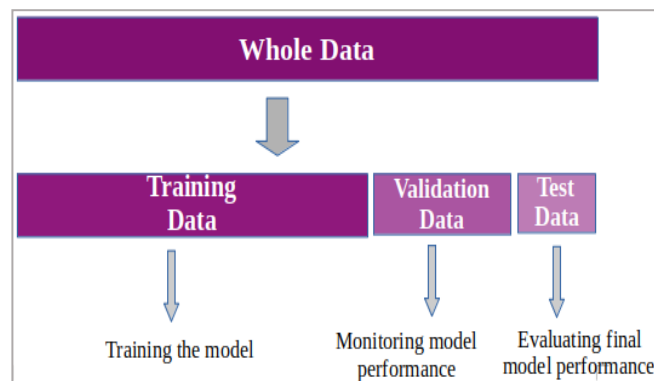


Fig. 3. Block diagram data classification

backpropagation and gradient-descent among others. Using gradient descent, we update the weights in the weight matrix for performing correct predictions. Using the loss function (L) along with the sigmoid function (used as the activation function for hidden and output layers) and with the help of chain rule derivatives, we compute certain equations to modify the weights correctly, improving the accuracy of the results. Then the trained system is provided with the validation data for monitoring its performance. Finally, unlabeled data (test data) is given to the system, using which the system allots a class from the provided number of classes based on its training. Hence, the complete data is divided into 3 parts: Training data, Validation data and Testing data.

#### D. Methodology:

This section provides information about the system and its working in detail. The working of the whole Lung Cancer Detection System is mainly divided into two stages. The first stage consists of pre-processing of the input image and in the second stage, these processed images are given as an input to the Convolutional Neural Network, which then screens all the possible pulmonary nodules in the PET images. The entire framework is implemented based on 2D CNN. The working is described in detail:

##### a. Image Pre-processing:

At this stage, the input image is first processed to get rid of the noise in the image. The pixel intensity of images is rescaled to (0,1) [12]. The pulmonary nodules being smaller in size, cannot be detected easily. The lung region is hence segmented on the basis of intensity and morphology. In order to decrease the computational cost of nodule detection, 2D axial slices are provided as an input to the neural network, instead of the 3D PET scan image [13].

##### b. Lung Nodule Detection:

The aim here, is to detect lung nodules at a high sensitivity, taking into consideration the size of nodules. The pre-processed image is fed to the CNN. A shallow Convolutional Neural Network consists of a limited number of hidden layers while the Deep Convnets include a series of hidden layers for complex data processing. Here, Deep Convolutional Neural Network is used as a deep model which can extract or build better features than the shallow models.



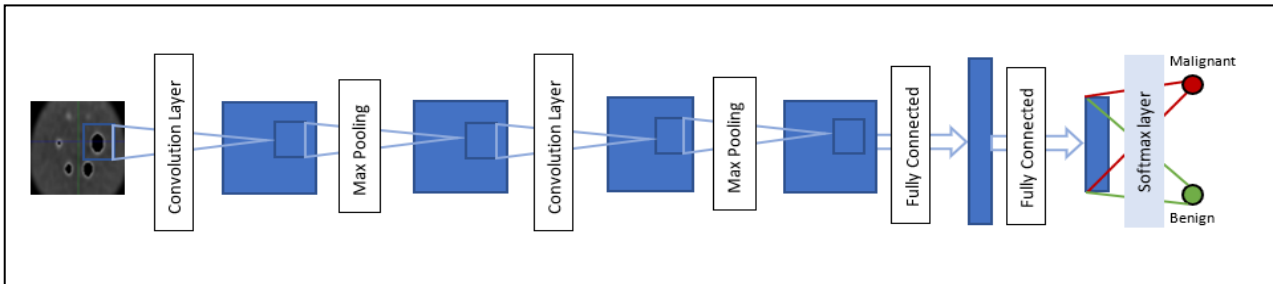


Fig 4. Architecture of CNN

Mathematically, convolution refers to a function which is derived from two given functions (by integration) which expresses how the shape of one function is modified by the other [14]. The Convolutional Neural Network consists of a number of layers including Convolution, Pooling and Fully Connected Layer.

Convolution, being the first layer of CNN, is an application of the filter to the input image matrix, resulting in activation. Repeated application of this filter to the input image generates a feature map which is a map of activations. This feature map indicates the location and strength of the feature; in this case, nodules, that has been detected in the input image. When the training dataset is fed to the convolutional layer, CNN automatically learns a number of filters which can be used on the testing dataset to identify presence of pulmonary nodules in the input image, using algorithms like gradient descent, backpropagation, etc.

Since the input images are grayscale images, the filters used are also 2D. Since large filters can only detect large objects precisely, smaller sized filters are chosen to detect small sized pulmonary nodules (3 X 3). The feature map generated is then given as an input to the ReLU, which is an activation function. This layer then introduces non-linearity in the output by bringing all the negative activations to zero. It simply computes the function:  $f(x) = \max(0, x)$ .

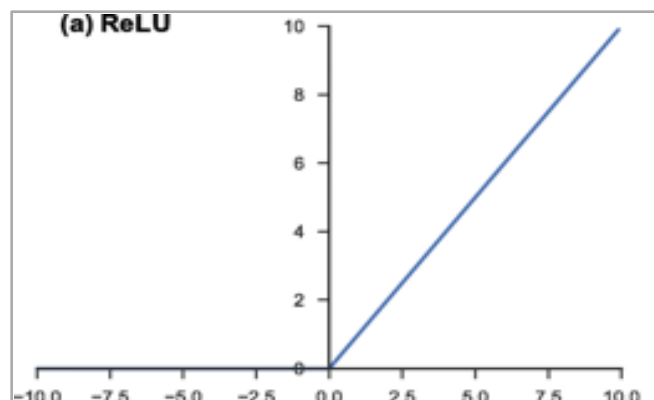


Fig. 5. Activation function: Rectified Linear Unit (ReLU)

Next, in the pooling layer, max pooling is performed, to reduce the size of the feature map without losing significant information. This avoids overfitting. The above two layers are stacked for obtaining precise and specific results. These reduce the complexity of the problem, which in turn reduces the processing time. The output feature map is then flattened and given as an input to the fully connected layer, which performs classification based on the features provided by the previous layer. Another activation function (SoftMax) is applied to the fully connected layer. It



# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 11, November 2019

normalizes the values from fully connected layer to generate probability distribution for detecting the presence of lung cancer. This is how, final prediction is made regarding the presence of cancer causing nodules.

## VI. CONCLUSION

To reduce the workload on the radiologists as well as to automate the process of detection of lung cancer, a system is built using convolutional neural network. Training datasets are used for training the newly built system, which identifies and generates different patterns using CNN. PET scan dataset is used as it provides colored images which proves more beneficial in detection of the malignant and benign tumor, based on their level of brightness.

## REFERENCES

- [1] W. L. Bi, A. Hosny, M. B. Schabath, M. L. Giger et. al., "Artificial intelligence in cancer imaging: Clinical challenges and applications," *CA, Cancer J. Clinicians*, vol. 69, no. 2, pp. 127\_157, 2019. doi: 10.3322/caac.21552
- [2] A. Hosny, C. Parmar, J. Quackenbush, L. H. Schwartz, and H. J. W. L. Aerts, "Artificial intelligence in radiology," *Nature Rev. Cancer*, vol. 18, no. 8, pp. 500\_510, 2018. doi: 10.1038/s41568-018-0016-5.
- [3] D. Shen, G. Wu, and H. Suk, "Deep learning in medical image analysis," *Annu. Rev. Biomed. Eng.*, vol. 19, pp. 221\_248, Jun. 2017.
- [4] Samuel G. Armato, Geoffrey McLennan, et.al., "The Reference Image Database to Evaluate Response to Therapy in Lung Cancer (RIDER) Project: A Resource for the Development of Change Analysis Software", *Clin PharmacolTher.* 2008 Oct; 84(4): 448–456. doi: 10.1038/clpt.2008.161
- [5] Bakr S, Gevaert O, Echegaray S, Ayers K, et. al., "A radiogenomic dataset of non-small cell lung cancer", *Sci Data.* 2018 Oct 16;5:180202. doi: 10.1038/sdata.2018.202
- [6] Zhang, Wei (1988). "Shift-invariant pattern recognition neural network and its optical architecture". Proceedings of Annual Conference of the Japan Society of Applied Physics
- [7] Fukushima, K. (2007). "Neocognitron". *Scholarpedia*. 2 (1): 1717. doi:10.4249/scholarpedia.1717
- [8] Hubel, D. H.; Wiesel, T. N. (1968-03-01). "Receptive fields and functional architecture of monkey striate cortex". *The Journal of Physiology*. doi:10.1113/jphysiol.1968.sp008455. ISSN 0022-3751. PMC 1557912. PMID 4966457
- [9] Fukushima, Kunihiko (1980). "Neocognitron: A Self-organizing Neural Network Model for a Mechanism of Pattern Recognition Unaffected by Shift in Position" (PDF). *Biological Cybernetics*. doi:10.1007/BF00344251. PMID 7370364. Retrieved 16 November 2013
- [10] Ian Goodfellow, YoshuaBengio, Aaron Courville, "Deep Learning", Genetic Programming and Evolvable Machines June 2018, Volume 19, Issue 1–2, pp 305–307, The MIT Press, 2016, 800 pp, ISBN: 0262035618
- [11] Neena Aloysius and Geetha M., "A Review on Deep Convolutional Neural Networks", April 6-8, 2017
- [12] Setio A, Ciomp F, Litjens G, et al., "Pulmonary nodule detection in CT images: False positive reduction using multi-view convolutional networks [J]. *IEEE Transactions on Medical Imaging*", 2016, 35(5):1160-1169.
- [13] Hongtao Xiea ,Dongbao Yang, et al., "Automated pulmonary nodule detection in CT images using deep convolutional neural networks", 85 (2019): 109–119.
- [14] Dominguez-Torres, Alejandro (Nov 2, 2010). "Origin and history of convolution". 41 pgs. <http://www.slideshare.net/Alexdfar/origin-adn-history-of-convolution>. Cranfield, Bedford MK43 OAL, UK. Retrieved Mar 13, 2013.
- [15] Patrice Monkam, Shouliang Qi, He Ma, Weiming Gao, Yudong Yao, (Fellow, IEEE), AND Wei Qian, "Detection and Classification of Pulmonary Nodules Using Convolutional Neural Networks: A Survey", *Digital Object Identifier 10.1109/ACCESS.2019.2920980*.
- [16] I. Ali, G. R. Hart, G. Gunabushanam, Y. Liang, W. Muhammad, B. Nartowt, M. Kane, X. Ma, and J. Deng, "Lung nodule detection via deep reinforcement learning," *Frontiers Oncol.*, vol. 8, p. 108, Apr. 2018. doi: 10.3389/fonc.2018.00108.
- [17] X. Liu, F. Hou, H. Qin, and A. Hao, "Multi-view multi-scale CNNs for lung nodule type classification from CT images," *Pattern Recognit.*, vol. 77, pp. 262\_275, May 2018.
- [18] Y. Qin, H. Zheng, Y.-M. Zhu, and J. Yang, "Simultaneous accurate detection of pulmonary nodules and false positive reduction using 3D CNNs," in Proc. IEEE Int. Conf. Acoustic, Speech Signal Process. (ICASSP), Calgary, AB, Canada, Apr. 2018, pp. 1005\_1009.
- [19] Y. LeCun, B. Boser, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard and L. D. Jackel: Backpropagation Applied to Handwritten Zip Code Recognition, *Neural Computation*, 1(4):541-551, Winter 1989
- [20] Sindhu R, Jose G, Shibon S, Varun V, "Using YOLO based deep learning network for real time detection and localization of lung nodules from low dose CT scans", February 2018, doi: 10.1117/12.2293699