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Automatic Benign and Malignant Classification of Pulmonary Nodules in Thoracic Computed Tomography Images based on CNN Algorithm

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ABSTRACT

The majority of the time, cancer symptoms only appear in the final stages of the disease, but with the use of advanced technology in which computer-aided systems, we can identify cancer at an early stage, then we may be able to treat it. These automated detection systems use a variety of machine learning techniques to identify lung cancer in its early stages. This type of automatic diagnosis of lung cancer is detected in computed tomography image modalities using convolution neural network. Compared to MRI and X-ray, CT pictures have the advantage of having less noise interference. Median filtering is applied to de-noising the CT scans to enhance the image quality. These pre-processed images are then fed through the Re-Lu layer CNN architecture. This architecture's several layers handle the feature extraction and categorization work. Different low-level and distinct high-level characteristics are extracted during the feature extraction phase. The classification layer is in charge of determining whether the presented image contains a benign or malignant, and it can able to classify the severity of malignance based on the infected area. To carry out the proposed model, CT image datasets are taken from Imaging data base Resource Initiative (IDRI) and Lung image Database consortium (LIDC) datasets. According to the findings, the suggested proposed system works with optimal results. The comparison demonstrates that the suggested proposed system outperforms the current cutting-edge technologies. The suggested proposed system will be beneficial for health care systems and medical diagnosis research. The proposed methodology is verified on MATLAB software.

Keywords : CT scan image, Malignant, Benign, CNN.

I. INTRODUCTION

One of the most prevalent and severe diseases affecting people is lung cancer. Uncontrolled division of aberrant cells, also known as tumors, is a hallmark of cancer. It involves abnormal cells in the human body growing and spreading. There are two types of these cells: benign and malignant. While malignant tumors [1] might pose a threat to life, benign tumors normally do not. In contrast to malignant tumors, which spread to other bodily cells to produce new cancerous nodules and have an irregular shape, benign tumors do not spread to other cells and are smooth and regular in shape. Older cells that become damaged are replaced by new cells as part of the normal biological process. When this mechanism fails and injured cells are not replaced, as a result cancer develops. Lung cancer [2] is treatable, if it detects in early stage.

The most deadly and prevalent disease that causes a significant number of fatalities each year is cancer. According to specialists, there will be more than 2.2 million new instances of lung cancer occur in 2022. Lung cancer has emerged as one of the leading causes of death among people. About 85% of male lung cancer instances and 75% of female lung cancer cases are caused by tobacco use and cigarette smoke. The second most frequent malignancy, according to reports is lung cancer.

Lung cancer can be diagnosed and detected using a variety of techniques, including blood tests, radiological exams, endoscopic procedures, and biopsies. Every test type has some benefits, some drawbacks, and some unique uses. Nonetheless, it's crucial to diagnose a disease early in order to treat lung cancer. Regrettably, early-stage lung cancer frequently exhibits no symptoms. In the later stages of the illness, symptoms arise. Yet, early diagnosis and detection of lung cancer result in a quicker recovery, a less expensive and difficult course of therapy, and a higher chance of disease remission. CT (computed tomography) scanning can give a quick, painless test result and information on the size and location of the tumor. Thus, the severity of lung cancer can be determined based on the size and location of the malignant nodule. A computer-aided diagnostic (CAD) [3] system is crucial in assisting radiologists in recognizing, forecasting, and accurately diagnosing lung cancer. These methods employ a variety of visual characteristics and machine learning algorithms to distinguish accurately between lung malignant nodules and benign nodules of a CT [4] image.

The remainder of the paper was organized as follows: section -2 provides an overview of the research conducted in this area by several authors, utilizing various machine learning techniques. The architecture of the proposed work is mentioned in Section-3 along with a thorough description. The execution and outcomes of the proposed work are covered in Section-4. Section-5 brings the conclusion to the proposed work.

II. RELATED WORK

Different methodologies and techniques have been studied, to implement the proposed work.

In [5] New CAD software was developed by the authors. 440 images were grasped arbitrarily from the LIDC , IDRI database. For the purpose of recognizing potential nodules from other structures and spotting them, the system employed the watershed technique. The histogram of oriented gradients (HOG) approach was employed, for feature extraction from lung image. It employed an SVM and a rule-based classifier to lessen false positives. They acquired 93.9% sensitivity by applying 10-fold cross validation.

In [6] Compare three various neural network topologies CNN, Deep Neural Network (DNN), and Stacked Auto Encoder (SAE). The author used the translation, rotation, and flip operations of image processing to obtain a larger sample data set of the input image because deep learning requires a lot of data. The output of these three architectures is then compared to one another on the same data samples in terms of sensitivity, accuracy, and specificity.

In [7] A approach is suggested for both detecting and predicting the possibility of lung cancer. The programme has performed a multistage categorization of cancer. SVM is used for classification, and each stage of classification involves individually enhancing the image and segmenting the image. If cancer is discovered, the appropriate stage designation is made, with the initial stage, middle stage, and terminal stage. If cancer is not found, the algorithm then determines if there is a chance that cancer could exist in that cell.

In [8] A standard 3D CNN classifier was put forth to distinguish between malignant and non-cancerous CT images. CT images are preprocessed with threshold techniques before applying to 3D CNN classifier. They were able to obtain an accuracy of 80% with this simple technique.

To differentiate between positive and negative instances, the Random Forest learning method computes and constructs a collection of various decision tree models. Each decision tree is created using a set of instances from a specified data set that have been randomly chosen [9]. A feature vector is compared to the collection of previously built decision tree models during prediction. All decision trees' predictions are gathered together. Based on the majority votes of all decision tree prediction results, the label for the feature vector is chosen.

III. PROPOSED METHODOLOGY

The proposed system is developed using CNN machine learning algorithm. A CNN become a popular machine learning algorithm. It is widely used not only in computer vision but also used natural language processing (NLP), image processing, and analysis of medical images. The proposed system's block diagram is displayed in below Figure.1. Giving a CT image as input to the system is the initial stage in this process. CT images undergoes several preprocessing processes such as filtering, binarization and morphological operations. After the completion of preprocessing CT image is given as input to the CNN classifier. Here, we employed the 70- layer CNN architecture. The training procedure is completed with the aid of this architecture. Getting output is the final stage.

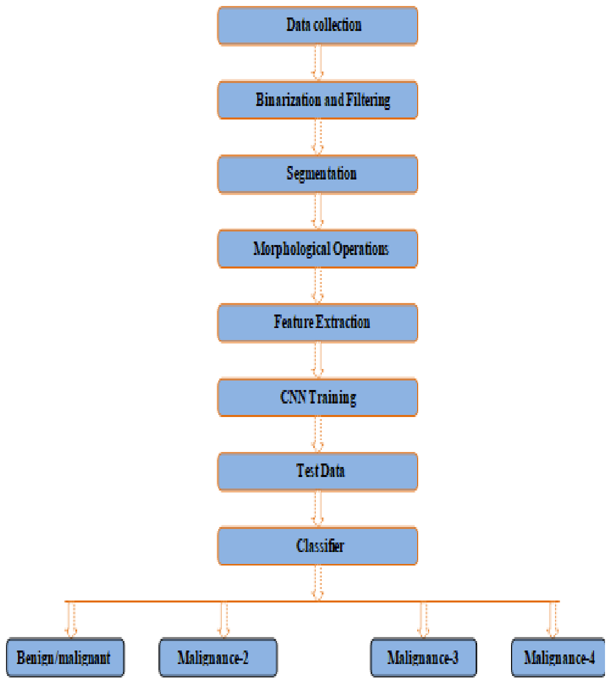

Figure. 1: Proposed system's Flow chart

A. Data Collection:

The initial phase is dataset collecting, during which we keep all CT scan images. A dataset of computed tomography images of patients with and without cancer had two different sorts of images. Dataset is grasped from LIDC-IDRI (Lung Image Database Consortium-Image Database Resource Initiative) [11]. Data collection contains 956 -CT images having cancer and 544 – CT images are non-cancerous.

B. Binarization and Filtering:

This section's main goal is to enhance the image by removing or compressing any undesirable noise or distortion. Here, there are two processes for image development and image smoothness. When CT pictures are taken from a machine, noise is introduced to the image. Noise is removed through image smoothing. Here, an undesired noise or distortion is removed with a median filter. The use of median filtering, which doesn't blur the image and keeps the edges while removing noise, is quite effective. The RGB image, which has three channels, is then converted to single-channel grayscale images. due to the fact that doing morphological techniques on Grayscale images is significantly simpler. With a single-layered image, it is also simple to differentiate features.

C. Segmentation:

We go through all of the CT pictures to identify which block contains suspicious content, for which segmentation is performed, to minimize the learning and training time. The suggested method uses segmentation based on the watershed technique. Based on pixel height, it separates images into various regions. We only train models with the regions that contain suspicious content in the abnormal CT Images-those are our regions of interest.

D. Morphological Operations:

A structuring element is introduced by morphological [12] procedures to a CT image input, to produce an output image while preserving shape and size. When performing a morphological operation, each output pixel's value is determined by comparing it to its neighbor pixels in the input image. To patch or remove holes from an image's edges, morphological techniques are used.

E. Feature Extraction:

From the segmented image we have to calculate the features of the tumor. In the proposed method textural features are extracted using HAAR wavelet. After extracting the features from the CT image then we train or develop the CNN model. After detecting the suspicious region, we are representing the infected area with the red color.

F. CNN Training:

The structure of Convolution Neural Network layer (CNN) is illustrated in Figure.2. Five convolution layers, five max-pooling layers, two normalization layers, four fully linked layers, and three SoftMax layer make up the architecture of our proposed CNN [10] algorithm. The Re-Lu activation function is used, which is non-linear and is also known as rectified linear activation function. Each convolution layer has convolution filters.

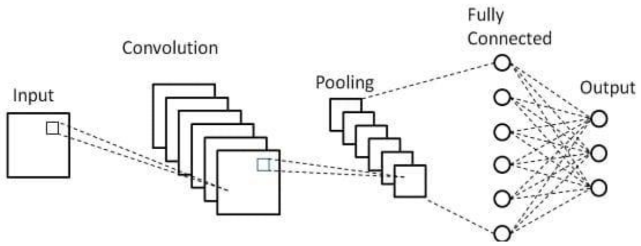

Figure 2: CNN layer Architecture

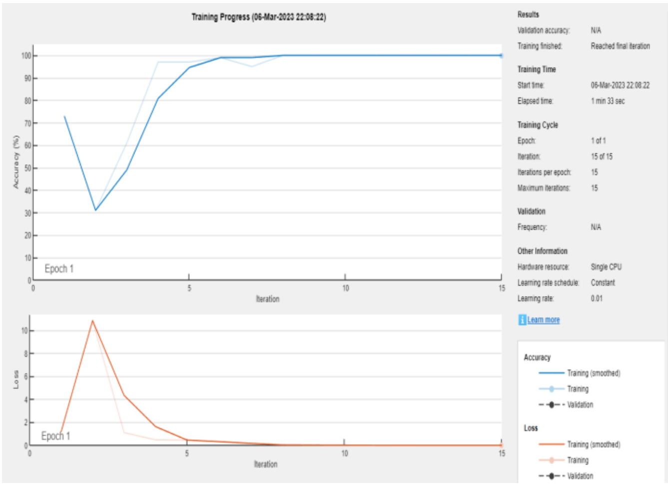

Figure 3: Training and loss graph

For training and validation purpose, we take 15 epochs and 0.01 as a learning rate in training. The training and loss graphs are displayed in Figure.3

G. Test data and Classification:

After developing or training the CNN model, a new test data is applied as an input to it, and it undergoes the above explained process, and with the knowledge of trained CNN model it classify test CT input as benign or malignance-2 or malignance-3 or, malignance-4. These malignance levels are classified based on the infected area. (Area is in terms of number of pixels)

IV. Results and Discussions

The proposed system is carried out with the help of the MATLAB software. One thousand five hundred CT pictures—956 malignant images and 544 non-cancerous images—are used in the proposed study as training to evaluate the suggested CNN architecture. The model has undergone testing and training over 15 epochs with a learning rate of 0.01. Our proposed system's performance is tested using the confusion matrix [13]. The proposed CNN architecture obtained 98.3% accuracy, 97.6% sensitivity, and 98.7% specificity. Along with these performance metrics other performance parameters also derived and these are compared with the existing model [9], which are shown in comparison table.

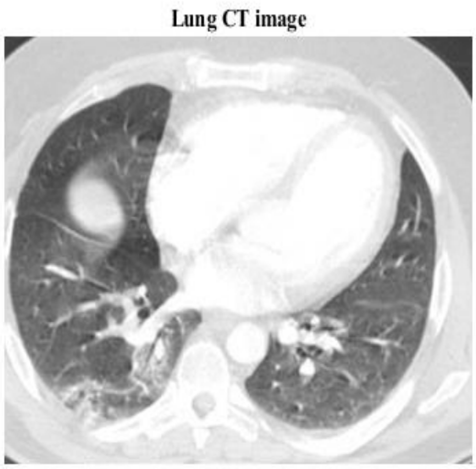

Figure 4: Input CT scan image

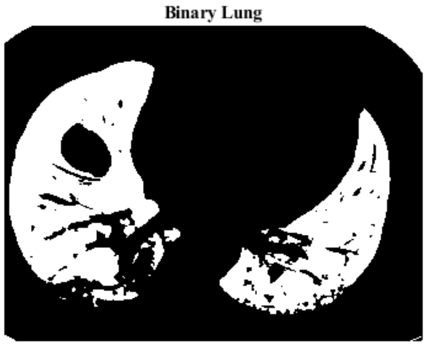

Figure 5: Binary format of input image

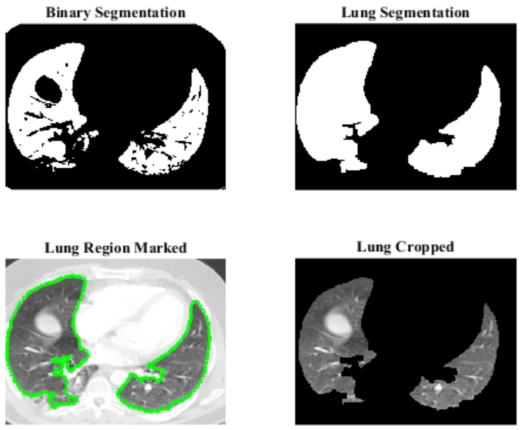

Figure 6: Image segmentation set

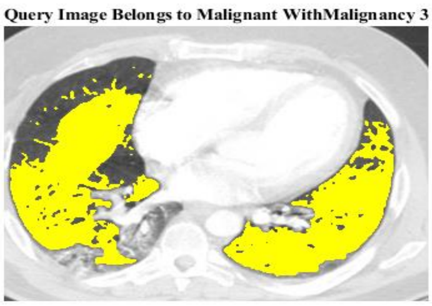

Figure 7: Image with Malignance

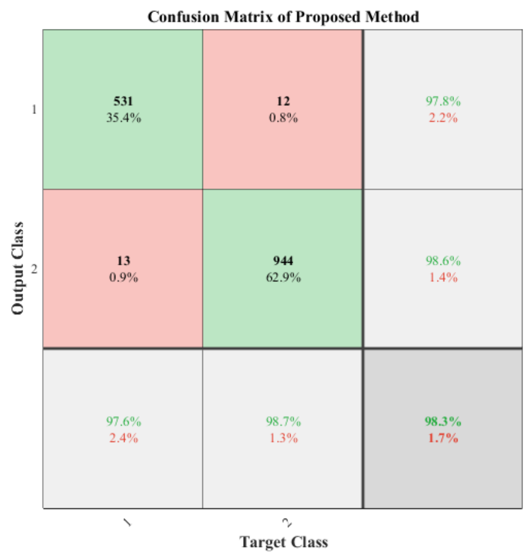

Figure 8 : Confusion matrix

Table Existing method vs Proposed method

Parameters	Existing-RF (%)	Proposed-CNN (%)
Accuracy	96.53	98.33
Error	3.46	1.67
Precision	95.38	97.79
Recall	95.03	97.61
False positive	2.61	1.25
Specificity	97.38	98.74
Correlation	92.49	96.39
Computation time (secs)	1.03	1.76

V. Conclusions

Lung cancer is still the foremost cause of cancer death in the world, with one of the lowest survival rates. Late diagnosis reduces a patient's chances of survival. This research utilizes CNN to accurately classify the malignancy level and benign cancer nodules present in lung CT scans. The key output in this paper is malignance level, this level is decided by the number of pixels exists in the infected area. If infected area having less than 10,000 pixels it classify output as a malignance with level two. If infected area having less than 17,000 pixels and more than 10,000 pixels it classify output as a malignance with level three. If infected area having more than 17,000 pixels it classify output as a malignance with level four. The LIDC-IDRI database was tested and the best results were obtained with the 98.3% accuracy, 97.6% sensitivity, and 98.7% specificity, which outperforms the results obtained with other technique. The proposed technique will be helpful in medical diagnosis research and health care system.

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