A Novel Long Short-Term Memory (LSTM) Deep Learning IoT Method for Lung Cancer Prediction and Detection

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Abstract

Lung cancer is the primary cause of cancer-related mortality in this generation, and it is expected to stay in foreseeable future. When the early indications of lung cancer are identified, a successful treatment can be initiated. A prototype environment friendly approach for treating lung cancer might be developed using the most recent developments in computational intelligence. Time and money will be saved since fewer resources will be wasted and manual tasks will take less effort to complete. An LSTM (Long Short-Term Memory)-based learning model was used to predict the lung cancer and improve the dataset procedure. With applications across medical image-based and textural data modalities, deep learning is one of the areas of medical imaging that is growing the fastest. Physicians may more easily and reliably identify and classify lung nodules with help of Deep Learning (DL)-based medical imaging technologies. This system covers the most recent advancements in deep learning-based imaging approaches for the early identification of lung cancer. The LSTM classifier sensitivity, specificity, and accuracy of our suggested system are best achieved by the Python software, with values of 80%, 85%, and 95%, respectively. Additionally, IoT (internet of things) to monitoring the lung cancer through cloud system through Adafruit Io. The lung cancer level is updating to NodeMCU controller.

Keywords: deep learning, LSTM; lung cancer; sensitivity; specificity and accuracy

1. Introduction

A grave worldwide health issue that is still pervasive and lethal is lung cancer. Lower death rates and improved patient outcomes are dependent on early lung cancer identification. Deep learning techniques can improve the precision and efficacy of lung cancer detection and prediction, it has

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been obvious in recent years. Healthcare is not an exception to how deep learning, a branch of artificial intelligence, has changed other sectors. Medical imaging data processing and evaluation have proven to be particularly well suited for convolutional neural networks (CNNs) and recurrent neural networks (RNNs). These neural networks are capable of conducting an extensive amount of radiological image analysis on their own, seeing minute patterns, and producing extremely precise predictions.

Deep learning has the potential to detect malignancies in their early stages, which is one of its main advantages in the identification of lung cancer. Deep learning models can discern subtle anomalies, micro calcifications, or irregularities in medical images that might go unnoticed by human radiologists. As a result, the technology can enable the early detection of lung cancer, when treatment options are more effective and less invasive. Deep learning algorithms also excel in reducing false positives and false negatives, addressing a long-standing challenge in lung cancer diagnosis. By meticulously analysing the features in radiological images, these models can significantly improve diagnostic accuracy, reducing the likelihood of unnecessary stress for patients and ensuring that potential cases are not overlooked.

The techniques provide valuable insights into the characteristics of lung tumors, and deep learning algorithms can help in more accurate interpretation and assessment. Deep learning's ability to process and interpret diverse patient data, including genetic information, clinical histories, and imaging findings, makes it a powerful tool for personalized medicine in lung cancer treatment. By considering individual patient profiles, deep learning models can assist healthcare providers in tailoring treatment plans to maximize efficacy and minimize side effects.

While deep learning holds immense promise in lung cancer prediction and detection, several challenges remain. These include the need for large, diverse datasets for training, ensuring ethical and secure handling of patient data, and addressing the interpretability of deep learning models in a clinical context. The integration of DL techniques into lung cancer prediction and recognition represents a transformative shift in the field of medical imaging. By leveraging the capabilities of deep learning algorithms, healthcare professionals can enhance early detection, accuracy, and personalized treatment, ultimately improving the prognosis for individuals affected by lung cancer.

2. Literature Review

The classification methods based on machine learning are used. ML techniques including ANN, KNN, and RF have been used for the classification. The ANN model can improve prediction of lung cancer [1]. An intelligent computer-aided system that uses ML approaches to diagnose lung cancer can be very beneficial to radiologists. A multistage classification is often used to predict lung cancer. The segmentation and data improvement categorization strategy are complete. Watershed and binary classifiers that are controlled by thresholds and markers are used in the segmentation process. Lung cancer can now be detected with greater precision [2].

By combining different perspectives from these collected data, machine learning-based algorithms have made it possible to combine and evaluate these enormous and complex datasets that have thoroughly described lung cancer. An explanation of machine learning-based techniques for early detection, auxiliary diagnosis, prognosis prediction, and the use of immunotherapy in the diagnosis and treatment of lung cancer [3].

Technology has greatly increased the accuracy of cancer detection. To address this issue, numerous computer-aided diagnostics (CAD) and systems have been proposed, created, and put into use. On the basis of image processing, a range of ML and DL approaches are integrated in these systems to predict the degree of malignancy in cancer. To categorize and recognize lung cancer in its early stages, a number of techniques will be applied, including feature extraction, picture segmentation, and feature analysis [4].

Comparisons of deep learning algorithms for lung cancer medical image analysis are made in terms of their performance, advantages, and disadvantages. The techniques that can be used for lung cancer classification and detection. Numerous techniques are also presented for gathering the images, extracting important details, segmenting the impacted areas, picking the best features, and categorizing the data [5].

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Using machine learning (ML) techniques, we created effective models for identifying people who have a high chance of developing lung cancer and intervening sooner to prevent long-term damage. This article recommends the Rotation Forest because tests using well-known measures, corresponding precision, recall, F-measure, accuracy, and area under the curve (AUC) [6], demonstrate that it performs well and earns high scores.

Those who are most likely to develop lung cancer in their lifetime can be identified using a more accurate screening procedure that makes use of AI capabilities. Clinical and laboratory data together with imaging features are being included into AI models that have the potential to predict patient outcomes, responses to certain medications, and the likelihood of adverse reactions. These clinical applications for lung cancer imaging rely on AI-based methods, and include automated lesion classification, segmentation, outcome prediction, and therapy response. [7-8].

An artificial intelligence (AI) model based on support vector machines (SVM) was applied to enhance the lung cancer dataset's detection technique. SVM classifiers are utilized to classify lung cancer patients into groups based on their symptoms, and Python is also employed to further model development. Multiple criteria were used to assess our SVM model's efficacy [9].

We hypothesize that the algorithm may have been developed to predict individual risk using the whole volumetric LDCT data without the addition of any additional clinical or demographic information. The National Lung Screening Trial (NLST) LDCTs are used to construct the Sybil model [10].

We reviewed a number of recent research on lung cancer and its different phases based on the history of patients' records. We learned that lung cancer poses a significant scientific difficulty in detecting the early stages of cancer disease. The lung cancer diagnosis accuracy of the deep learning and CNN model created by this research was astounding [11]. One of the deadliest diseases that has to be promptly diagnosed is lung cancer.

Artificial intelligence has shown to be crucial in the medical industry in general and in the diagnosis of diseases in particular since it eliminates human errors that could occur when a medical expert examines a medical image. The evaluation's recommendations for creating diagnostic instruments that employ DL algorithms have the potential to save lives. The four databases concentrate on the academic components of lung cancer diagnosis and nodule categorization. [12].

It has been proposed that physicians should use machine learning-based lung cancer prediction algorithms to treat ambiguous pulmonary nodules found accidently or during screening. These methods improve decision-making, reduce categorization variation, and reduce the frequency of benign nodules that require pointless monitoring or probing [13].

Lung cancer screening techniques based on machine learning have been contrasted. There are now more ways than ever to diagnose lung cancer, most of which rely on CT scan images and a few others on X-ray images. To diagnose lung cancer nodules using image recognition, a number of segmentation methods are paired with a range of classifier techniques [14].

DL methods for diagnosing lung cancer were thoroughly examined. Deep learning models like Convolutional Neural Network (CNN) are increasingly chosen for processing lung CT or MRI data for disease judgment as a result of significant advancement. When lung cancer is detected early, it can be better treated and eventually cured. Clinical decision support systems (CDSSs), which are crucial for healthcare organizations, can be developed using a number of characteristics of lung cancer detection as a starting point [15].

Healthcare research has advanced thanks to artificial intelligence. Open-source healthcare statistics are available; therefore, academics have developed tools to help in cancer diagnosis and prediction. When treating such complicated diseases, deep learning and machine learning models provide a trustworthy, quick, and effective solution. F1-score, detection rate, undercover area, precision, recall, sensitivity, and accuracy were all used to complete the comparison [16].

Five cycles of cross-validation were used to evaluate the trained DL-based model on the training dataset. Using the independent test dataset, the model's sensitivity and mean false positive indicators per picture (mFPI) were evaluated. The low mFPI of the DL-based model suggests that lung cancers may be detectable on chest radiographs. [17].

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A CAD model could highlight problems that doctors might have missed during their initial evaluation. using commercially available computer-assisted detection (CAD) software powered by artificial intelligence (AI) from various vendors, physicians would be more successful in spotting lung cancer nodules on chest radiographs. The level of chest radiological expertise of the doctors. The readers individually analyzed the radiographs at first, then they reinterpreted them using the CAD output [18].

The capacity of AI-based algorithms to discriminate between COVID-linked pneumonia and lung cancer CT scans with COVID-19 promptly and precisely [19]. AI- has increasingly been applied to imaging diagnosis as science and technology have advanced. An echo logistic study that included a massive amount of new data evaluated the usefulness of artificial intelligence for identifying lung cancer. An echo logistic study that included a massive amount of new data evaluated the usefulness of artificial intelligence for identifying lung cancer using STATA16.0 [20].

The metrics for measuring and evaluating the model performance outcomes include sensitivity, specificity, accuracy, the ROC curve, and the area under the curve (AUC). With low false positive results and good performance of accuracy using cutting-edge hybrid deep-learning model excels [21]. To speed up this cancer detection, DL and ML approaches are used [22].

Deep learning algorithms produce better results than conventional methods do. Various deep-learning methodologies are now being tested by researchers to improve the effectiveness of CAD systems for computed tomography-based lung cancer diagnosis [23]. For healthcare applications, deep learning (DL) is a revolutionary method that offers outstanding speed and better accuracy.

Blockchain and the "convolutional neural network" (CNN), also referred to as a CNN, are two essential elements that cooperate to secure and accelerate the disease detection processes. CNN and the blockchain may be used to evaluate the quality of food, and diseases like lung cancer might be identified and predicted [24-28].

Using a particle swarm optimization technique, learning ability (loss and accuracy) is further improved. This level makes use of the Internet of Medical Things (IoMT) to transmit medical data (CT scan and sensor information) [29-30].

3. Proposed Methodology

The proposed methodology for lung cancer prediction and diagnosis using preprocessing, segmentation and classification approaches includes efficient output in medical images. The first step is to collect the dataset from any website, then further processing implements image filtering, segments the image, and finalizes classification, either for disease or not. The training and testing images are transfer to nodemcu through the serial communication. After that the data visualize in Adafruit io application. The overall working process shown in figure 1.

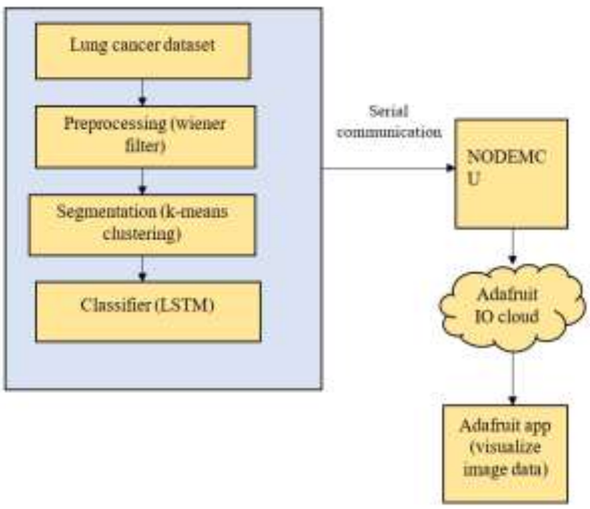

Figure 1: Flow diagram proposed lung cancer detection.

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Preprocessing: Wiener filter

Pre-processing refers to the modifications done to our data before we give it to the algorithm. Unclean data may be converted into clean data sets via a process known as data preparation. In other words, if data are gathered from several sources, they are done so in a way that makes analysis impossible.

The Wiener filter's objective is to get rid of noise that distorts the signal. It is grounded in statistical math. The usual frequency response of a filter is determined. The Wiener filter, on the other hand, was created using a special technique. Finding the linear time-invariant filter whose output would be potentially closest to the original signal requires knowledge of the spectral characteristics of both the original signal and the noise.

The expression of wiener filter in mathematical form is given below:

$$W(m_1, m_2) = \frac{H^*(m_1, m_2) S_{xx}(m_1, m_2)}{|H(m_1, m_2)| S_{xx}(m_1, m_2) + S_{nn}(m_1, m_2)} \quad (1)$$

Here, $S_{xx}(m_1, m_2)$- power spectrum of original image,

$S_{nn}(m_1, m_2)$- Additive noise

$H(m_1, m_2)$- blurring filter

The power spectra of the original picture and the additional noise must be estimated in order to actually apply the Wiener filter. White additive noise's power spectrum is the same as the noise variance. There are several techniques that may be used to approximate the original image's power spectrum. The period gram estimate of the power spectrum calculated from the observation is a direct estimate.

$$S_{yy}^{per} = \frac{1}{N^2}[Y(k,l)Y(k,l)^*] \quad (2)$$

$$S_{xx} = \frac{S_{yy} - S_{nn}}{|H|^2} \quad (3)$$

The cascade implementation of noise smoothing and inverse of noise filter can be estimate using below this formula,

$$W = \frac{1}{H} \frac{S_{yy}^{per} - S_{nn}}{S_{yy}^{per}} \quad (4)$$

Image Segmentation: K means clustering

A group of predetermined pixels fundamentally make up a picture. When segmenting a picture, pixels with similar characteristics are grouped together. For each item in an image, image segmentation develops a pixel-wise mask that provides a more thorough and detailed description of the object.

Identifying the external contour and voxel information of the region of interest is the aim of image segmentation. Medical imaging typically uses segmentation to divide organs or lesions into smaller groups in order to statistically assess pertinent clinical data and provide further assistance for subsequent diagnosis and treatment.

K Means is a clustering method. There are no labeled data available since clustering techniques are unsupervised algorithms. It is used to detect several groups or clusters within the supplied data based on how similar the data is. It is easier to compare data points within the same group than it is to compare them to data points in other groups. Due to the centroid-based nature of the approach, a centroid is allocated to each cluster. Reducing the overall distances between each data point and the clusters that are related to it is the main objective of this strategy.

One of the image segmentation techniques is the clustering algorithm, which is mostly used for the segmentation process and is most popular because it requires less computation time and is simple to construct. A data-partitioning procedure called K-means clustering iteratively allocates n observations to precisely one of the k groups determined by centroids.

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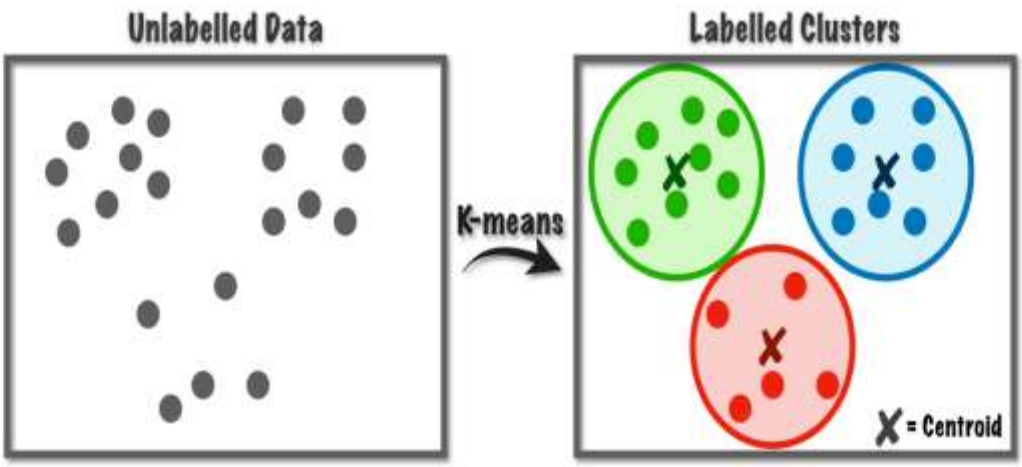

Figure 2: k- means clustering algorithm

Let, the data points are set in up to n is $Y = \{y_{1,}, y_2, y_3, \dots y_n\}$and to select the cluster centers up to m point is $C = \{c_{1,}, c_2, C_3, \dots c_m\}$. The m cluster center is where the n data points are to be grouped.

The objective function of clustering algorithm,

$$J = \sum_{i=1}^{n} \sum_{i=1}^{m} \parallel y_i - c_j \parallel^2 \quad (5)$$

Here, $k - no. of\ data$

$n - Total\ no. of\ data,$

$c_j = cluster\ center,$

$y_j = \ data\ point,$

The K-means method can identify more classes or clusters of colors as the value of k increases, making the image more distinct and clearer.

Classification: LSTM (long short-term memory)

The classification method of supervised machine learning is asking the model to choose the right label for a collection of input data. The model is fully tested against the test data, evaluated against the training data, and then used to generate predictions on brand-new, unused data when doing classification.

Recurrent neural networks (RNNs) of a specific form called long short-term memory (LSTM) are used to deal with sequential data, such as time series, audio, and text. Because they can recognize long-term patterns in sequential data, LSTM networks are particularly well suited for applications like language translation, speech recognition, and time series forecasting.

Since an LSTM's fundamental structure explicitly records and propagates unit outputs over a number of time steps, it is referred to as a memory cell. The LSTM memory cell makes use of cell states to retain data about time-based situations. To regulate the information flow between different time steps, it also has forgot, input, and output gates. In this study, time-series meteorological data were used to train LSTM-based neural networks to predict background radiation. The "problem of vanishing gradient" refers to the difficulty in comprehending the long-term interactions in the structure of recurrent neural networks from a mathematical perspective.

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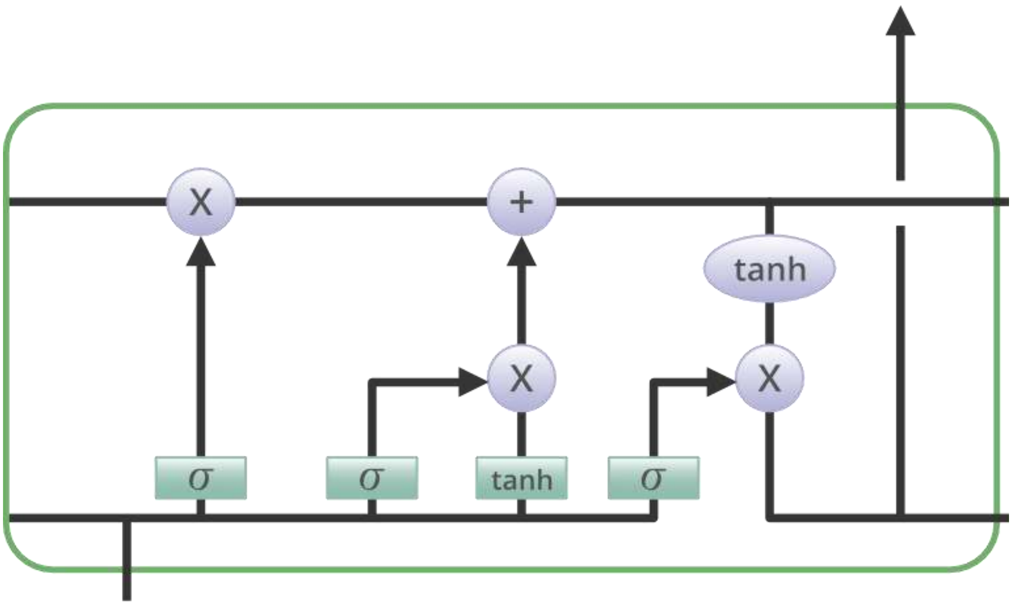

Figure 3: Architecture of LSTM

The hidden Layer express the mathematical formula,

$$h_{(l)} = f(h_{l-1}, x_l) \quad (6)$$

$f - Activation\ function,$

The forget layer of including in sigmoid,

$$f_l = \sigma(W_f.[h_{l-1}, x_l] + b_l) \quad (7)$$

$\sigma - sigmoid\ function,$

$x_l - input\ value,$

$W_f - forgot\ gate,$

$b_l - bias\ value,$

$h_l - outpput\ value.$

The sigmoid function is represented that the mathematical form,

$$\sigma(y) = \frac{e^y - e^{-y}}{e^y + e^{-y}} \quad (8)$$

The model then decides what information will be suppressed. The two layers that make up this process are the input gate layer and the sigmoid layer. Each layer acts as a guide for determining which values will be changed, and it also generates a vector that might contain new value possibilities. Combining these two processes results in a new input value.

$$i_t = \sigma(W_i.[h_{t-1}, x_t] + b_i) \quad (9)$$

$$\bar{C}_t = tanh(W_c.[h_{t-1}, x_t] + b_c) \quad (10)$$

$$C_t = C_t * C_{t-1} + i_t * \bar{C}_t \quad (11)$$

Sigmoid gates were used to choose the output value,

$$O_t = \sigma(W_O.[h_{t-1}, x_t] + b_O) \quad (12)$$

$$h_t = O_t * \tanh(C_t) \quad (13)$$

Here,

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$tanh - scale\ value,$

W_i − weight input gate,

$\bar{C}_t$ − added cell state,

C_t − cell state,

b_O −bias cell state,

$O_t - output\ gate.$

IoT (internet of things)

The lung cancer image dataset, through preprocessing, segmentation, and classifiers, is evaluated by the nodemcu controller. This controller transfers the image to the cloud system. The Adafruit app visualizes lung cancer and how it impacts the lung.

The phrase "internet of things" refers to a system of networked devices that share information with one another, with other IoT devices, and with the cloud. IoT devices often comprise technology like sensors and software. These devices can be consumer goods as well as mechanical and digital equipment.

Businesses across a range of sectors are increasingly utilizing IoT to enhance operations, customer service, decision-making, and overall corporate value. With IoT, data may be sent over a network without the need for computer to computer or person to person connection.

Adafruit Io

Let's examine Adafruit IO and how it works now that you are more knowledgeable with the Internet of Things and cloud computing. The popularity of IoT cloud deployments has increased alongside the rate of digital transformation.

One such cloud service provider that focuses primarily on IoT distributions on the cloud is Adafruit IO. Different hardware, including Raspberry PI, ESP2866, and Arduino, is supported by Adafruit IO

4. Result and discussion

The dataset was collected from the Kaggle dataset, which has the training and testing images for performance metrics through the predictive data. Performance metrics such as sensitivity, specificity, and accuracy are discussed below. This is done by converting class label and nominal attribute data into binary form, which facilitates data analysis. Classifiers are employed when historical data has to be translated into a format that can be utilized for categorization. It is a powerful tool for data analysis that enables you to perform ten times as many computations with the available data and generate exact predictions based on that data as is practical with conventional techniques. The proportion of accurate predictions that are created from a complete forecast is known as a forecast's categorization accuracy. The results of the experiment will determine the values of these variables. These are implements in python tool which is more accuracy of predicated data.

Sensitivity

Sensitivity is state that true Positives are predictions that come true, whether they were rightly called positive or falsely called negative, in terms of the overall number of positives.

$$Sensitivity = \frac{TP}{TP + FN}$$

Specificity

The quantity of genuine positive conditions a person can recollect gives us an accurate prediction from our system. The recall makes sense when False Negative outperforms False Positive.

$$Specificity = \frac{TN}{TP + FN}$$

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Accuracy

Accuracy is defined as number of correct predictions to total number of predictions. It is easy to evaluate the classification for implementation of data.

$$Accuracy = \frac{TP + TN}{TP + TN + FR + FN}$$

The comparison analysis of lung cancer detection analysis in python software to produce the better result sensitivity, specificity and accuracy values are explored in table 1

Table 1: Comparison methods of LSTM with SVM and KNN

Methods	Sensitivity	Specificity	Accuracy
SVM	75%	72%	70%
KNN	78%	76%	90%
LSTM	80%	85%	95%

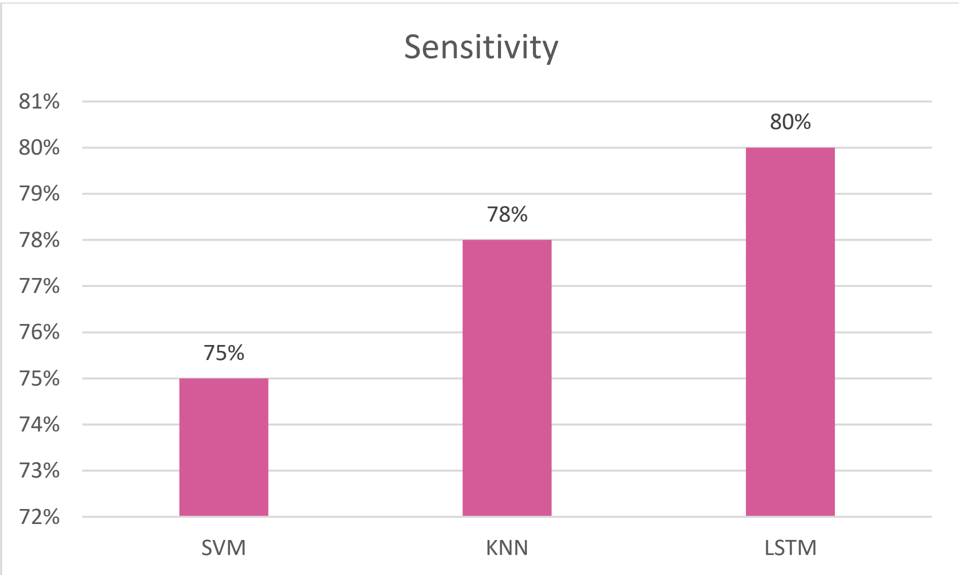

Figure 4: Sensitivity analysis of lung cancer

The lung cancer prediction using LSTM algorithm used comparative analysis with SVM and KNN algorithm to produce the sensitivity values are 75%, 78% and 80%, respectively. The three algorithms are analysis to achieved the high sensitivity in LSTM 80% compared to SVM and KNN which shows in figure 4.

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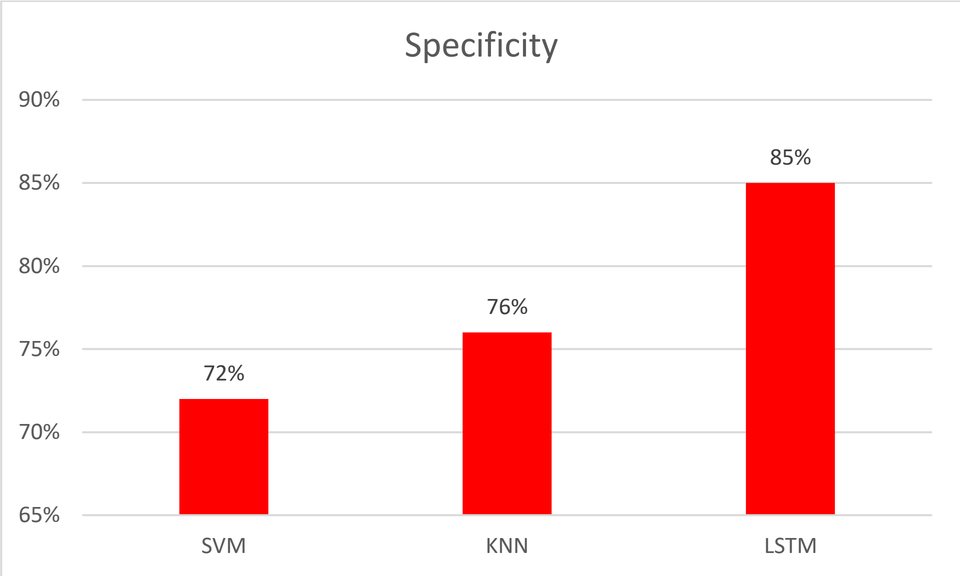

Figure 5: Specificity analysis of lung cancer

The lung cancer prediction using LSTM algorithm used comparative analysis with SVM and KNN algorithm to produce the specificity values are 72%, 76% and 85%, respectively. The three algorithms are analysis to achieved the high specificity in LSTM 85% compared to SVM and KNN which shows in figure 5

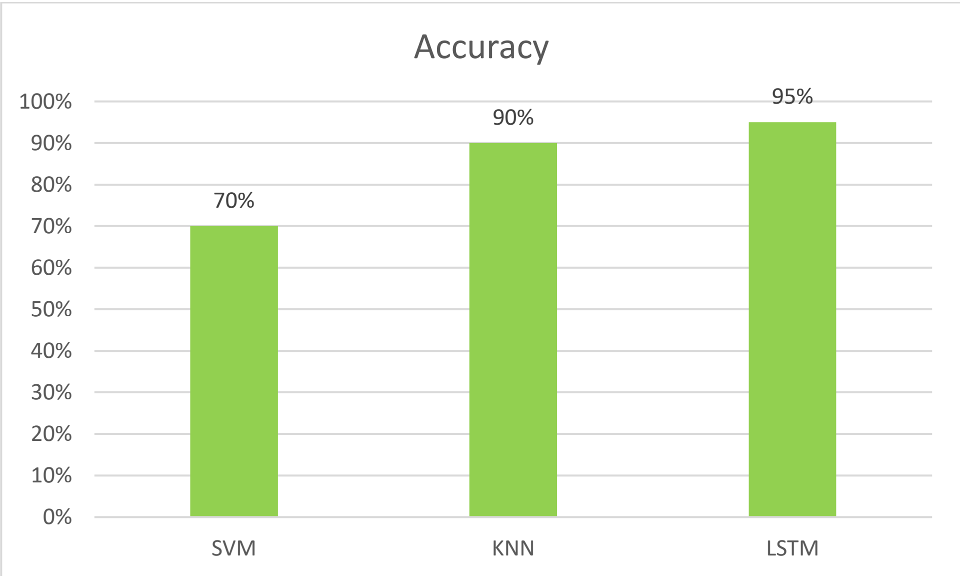

Figure 6: Accuracy analysis of lung cancer

The lung cancer prediction using LSTM algorithm used comparative analysis with SVM and KNN algorithm to produce the accuracy values are 70%, 90% and 95%, respectively. The three algorithms are analysis to achieved the high accuracy in LSTM 95% compared to SVM and KNN which shows in figure 6.

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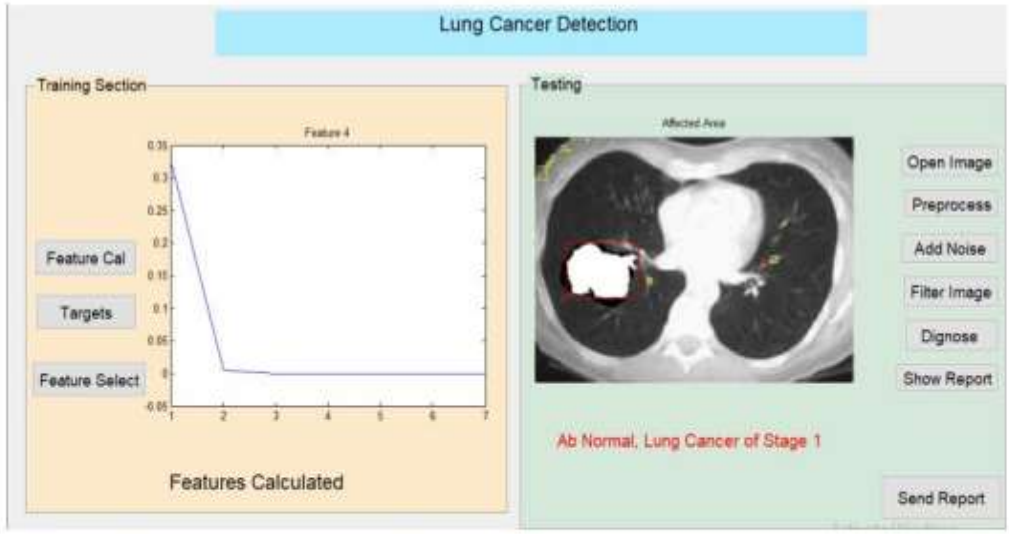

Figure 7: lung cancer visualizes in Adafruit

Figure 7 represents the data transfer in the Adafruit application after applying machine learning algorithms such as preprocessing, segmentation, and classifiers. Adafruit is one of the IoT technologies with open-source services.

5. Conclusion

Our work concentrated on recent developments in deep learning-based methods for classifying and segmenting lung cancer. The most popular imaging data sets for training networks are image datasets, and CNN is one of the most used deep learning algorithms for diagnosing and categorizing lung disorders. Deep learning is expected to greatly enhance lung nodule segmentation, detection, and classification. Using this Python script, radiologists may more thoroughly assess pictures. The deep learning algorithm has shown great promise in a range of radiology department operations and has supplied answers to several medical problems. The LSTM classifier that produces the best result has sensitivity, specificity, and accuracy of 80%, 85%, and 95%, respectively. The IoT technology implemented in Adafruit io system based on the Adafruit cloud was efficient visualize the lung cancer image data.

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