A Novel Approach based on Average Information Parameters for Investigation and Diagnosis of Lung Cancer using ANN[1]

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Abstract—In this paper, an average informational parameter based approach for lung cancer detection and diagnosis has been proposed. Suggested methodology is established on average information parameters by utilizing image processing tools for lung cancer investigation. The real issue with the lung cancer diseases is the time constraint for physical diagnosis that expands the death possibilities. Henceforth essentially proposed technique is an approach that would help the medical practitioners for precise and superior decision against the lung cancer discovery. The crucial point in the proposed method is that it helps the doctors for taking a firm decision on lung cancer diagnosis. Microscopic lung images are taken for analysis and investigation by using digital image processing techniques which also recovers the quality of images that has been degraded by several reasons including random noise. The statistical parameters are implemented for lung cancer analysis. The statistical and mathematical parameters are implemented like Entropy, Standard Deviation, Mean, Variance and MSE under average information method. The statistical range of each parameter is calculated for number of iterations. The individual statistical parameter analysis with its impact on lung cancer images is carried out and finally the Artificial Neural Network is the final decision maker in lung cancer diagnosis. This paper also rejects the null hypothesis test by implementing one of the standard statistical methods.

Keywords: Average Information, Statistical parameters, Lung cancer, ANN, ANOVA

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1. INTRODUCTION

Lung cancer seems to be a very common cause of death among the people all over the world. Lungs are the essential element of the respiratory system and are best responsible for working the human body. For typical growth, units in the lungs divide and imitate in a controlled rate on restore wounded tissues of the fit body. Lung malignancy reported in [1, 2] suggests that the point when cells inside those lungs increase in wild rate. These abnormal tissues of the lungs prompt tumor-lung cancer. Today lots of medical imaging techniques given in [1–3] are accessible by radiologists and medical practitioners for the diagnoses of lung cancer for example- X-ray, Computer Tomography (CT), High Resolution, Computer Tomography, Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and Biopsy. As these radiological techniques have some advantages and at other end detriments, which does not provide any complete declaration around the lung cancer. Moreover, time factor is very important for making the decision about the mitigation for suffering patient. Consequently there is a strategy that will help the radiologist to get flawless outcomes. By these medicinal imaging techniques, particular case that's only the tip of the system that is actualized to lung cancer finding is the biopsy [4]. It is simply a conclusive approach to lung cancer analysis. Imaging tests are to be used to figure out if those growths spread, yet fails to offer exact lung cancer analysis. The biopsy is a procedure for which a little measure from claiming lung tissue is made for examination under electron magnifying instrument such as microscope. The biopsies and surgical operations imaging strategies aid are exceptionally imperative in the dissection about lung malignancy and cancer. However, no test will be ideal, and no examine might diagnose lung cancer; in any case biopsy could do that. Yet all over again biopsy need exactly drawbacks that incorporate trouble over breathing, excessive bleeding oozing out and additionally there will be a constantly chance for spreading of growth cells in the lungs and moreover different parts of the body due the

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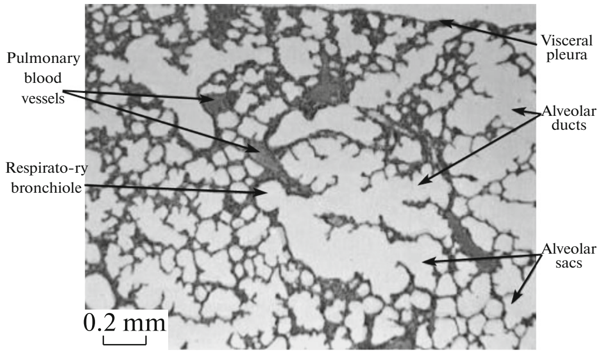
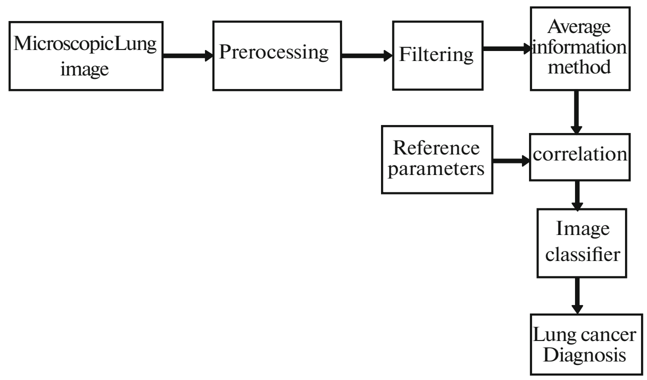


Fig. 1. Sample Microscopic Lung image.

(a)



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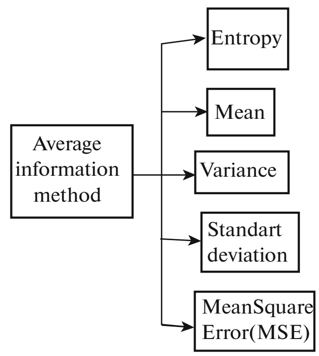

Fig. 2. (a) Flow Diagram of the Average Information Method, (b) Average Information Parameters.

removal of small part of tissue and hence considered as the last choice for the cancer diagnosis. It is often recommended when no different scan meets expectations.

This microscopic lung picture is acknowledged for the analysis and diagnosis, is acquired through biopsy made through Electron Microscope [5], which is a capable magnifying instrument that permits the researchers and specialists to perspective the example of the lung in nano gauge level. A little bit about of lung tissue may be taken, settled in to paraffin, slice thin, put once a glass slide, et cetera reagent is utilized within treating an example for minute examination.

The resultant preparations are analyzed under magnifying instrument like Electronic Microscope to lung cancer examination and analysis. The pictures that would get through this methodology are known as microscopic lung images concerning illustration seen over Fig. 1. Magnifications of these depicted images could be up to 400 times or indeed additional which is exceptionally of service to the medicinal analysis. It is exceptionally troublesome to visualize those microscopic and take decisions as it may go wrong in number of cases, subsequently obliges a robust strategy. Image transforming and processing with MATLAB will be excellently useful package in taking care of the microscopic images. The average information method using statistical parameters is carried out for lung cancer analysis. The image classifier tool is utilized for final decision which is reported in next sections.

2. PROPOSED METHODOLOGY

There are lot of issues with ordinary lung cancer analysis utilizing medicinal imaging systems for example, such that lot of symptoms of lung cancer are similar to the other lung diseases which creates confusion in the mind of patient and rechecking process is tiresome and complicated and if found certain substantiation of lung cancer then biopsy process of diagnosis is performed. Because of over issues a supporting technique must be required for therapeutic imaging systems. The technique utilized here is the development of the algorithm utilized in [6], to which the factual statistical parameters utilized were Entropy, Standard Deviation and texture factor for lung cancer analysis and diagnosis. These parameters were used to differentiate lung cancer from other lung diseases, as well as used for lung cancer analysis.

Proposed system includes addition of some more parameters under the investigation so as to enhance those executioner performances.

Block diagram of proposed Average Information Method for lung cancer analysis is shown in Fig. 2. Determination of the parameters under this system may be in view of their average figuring principle utilized for the statistical analysis. In the proposed method, the parameters used are Entropy, Mean, Variance, Standard Deviation and Mean square Error.

Normalized gray scaled image with size of 255 × 255 is formed from the microscopically captured lung image and utilized for further processing and investigation practice. These images are preverified as cancerous and non-cancerous lung images. Images have been enhanced by adopting the Median filter. It is an averaging filter which not only removes the noise contents, but also provides smoothing by removing those pixels showing sudden changes form the captured microscopic image. Average information technique is applied on these filtered-noise free images to extract the valuable statistical information of cancerous lung particles. Based on the reference parameters of the same system, correlation examination has been carried out for determination of lung cancer under the tissue to be examined.

2.1. Database

Microscopic Lung image [10] database is used in this paper to evaluate the performance of proposed algorithm. The database is of 323 lung images, checked and pre-verified from Physician and radiologist expert. Out of 323 images, 101 images are noncancerous lung images and remaining 222 are cancerous.

2.2. Statistical Analysis

Factual investigation has been recognized by adopting a powerful tool known as statistical analysis which covers that essential majority of the data of the picture taken by the Electronic Microscope. Statistical analysis [6, 7] is actually that investigation applicable for irregular-random information. It does not attempt to see the structure from claiming picture however gives the deterministic properties which provide for that association between gray levels from a picture. In proposed system, random pattern of lung cancer has been distinguished by means of random data. Statistical analysis feature have potential of effective structure discrimination or disorder in biomedical images. Various significant statistical parameters are associated with the statistical analysis; the scan be analyzed against cancerous microscopic lung images to get appropriate range for lung cancer analysis. The range obtained through the number of iterations are carried out and is limited for the specific database of microscopic lung images only.

2.2.1 Average Information method. The technique is based on averaging of the intensity levels for every pixel position in the image. Each scanned image has two segments, that is steady indicator-signal part and irregular-random noise component part. In the averaging process, signal component stays unchanged, yet the noise component part varies with frame to frame. Since the noise is irregular, it tends to neutralize while performing out the summation. At the point it is figured out that, the picture signal part has parcel of impact over the summation when contrasted with the noise segment.

In light of a similar recommendation, all the factual-statistical parameters under this are chosen. The after effect of the parameters breaks down the harmful and ordinary lung pictures. The parameters under average information are as follow [6–8].

a) Entropy: It indicates average information of the image. The lowest value of entropy means no uncertainty of the image information.

$$E = -\sum_{x}^{m}\sum_{y}^{n} P[x, y]\log P[x, y], \tag{1}$$

$P[x, y]$ is the probability difference between two adjacent pixels and log is the base 2 logarithm. Deliberating Entropy $E = 0$ if $P = 0$ or 1. Entropy is calculated by equation (1).

b) Mean: It calculates the mean of the gray levels in the image. Mean depends on the first moment of the data. Technically, a moment is defined by a mathematical formula that just so happens to equal formulas for some measures in statistics. First moment is the mean which is represented as in equation (2) and (3)

$$S^{th} = \frac{(x_1^s + x_2^s + x_3^s + \ldots x_n^s)}{n}. \tag{2}$$

First moment ($S = 1$)

$$S^{th} = \frac{(x_1^1 + x_2^1 + x_3^1 + \ldots x_n^1)}{n}. \tag{3}$$

This formula is identical to the formula to find the sample mean. Just add up all of the values and divide by the number of items in given data set. The mathematical expression of mean is given as in equation (4)

$$\mu = 1/N * M\sum_{x=0}^{M}\sum_{y=0}^{N} P[x, y]. \tag{4}$$

c) Variance: It explains about the distribution of gray levels over the image. The value of the Variance is expected to be high, if the gray levels of the image are spread out extensively. It explains about the probability of distribution, describing how far the value lies from the mean that is anticipated value, which can also be defined as the moments of a distribution. Second moment ($S = 2$) is given as by equation (5). The second moment is the Variance. μ_x is the average of x. Mean provides each pixel intensity for the whole image, whereas the variance gives each pixel variations form the neighboring pixels and is use to classify image into different regions or areas. It is the average of the squared differences from the mean. It is the variability around the value.

$$S^{th} = \sum (x_i - \mu_x)^2. \tag{5}$$

The mathematical expression for calculating Variance is given in equation (6), $N - 1$ can be changed to N if the $\bar{x}$ is known prior rather than being estimated from the data

$$\text{var} = \sigma^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x}). \tag{6}$$

d) Standard Deviation: If the value of standard deviation is less which means that the majority of the data is near the mean value and if it is more that means data is highly distributed over the image. The value of standard deviation is assigned to the center pixel of the image. All the steps are similar to calculate the standard deviation as the variance, only the last step is added as the square root, hence is the square root of the variance represented by equation (7)

$$SD = \sigma = \sqrt{\sigma^2}. \tag{7}$$

e) MSE (Mean Square Error): The MSE represents the averaging of the squares of the errors between the two images [9]. The error is the amount by which the values of the reference image differ from test image calculated form equation (8).

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}[f(i,j) - g(i,j)]^2. \tag{8}$$

$f(i, j)$ represents the matrix data of original image and $g(i, j)$ represents the matrix data of test image. m represents the numbers of rows of pixels of the images and i represents the index of that row n represents the number of columns of pixels of the image and j represents the index of that column. MSE for the practical purpose allows comparing the true pixel values of original image to cancerous image.

2.3. Correlation

Correlation is an additionally a statistical procedure which demonstrates how factors are robustly related with each other. It extracts necessary information from the image. It is used to find the location in an image that is analogous to the reference image. Correlation is a measure of gray level linear dependence between the pixels at the specified positions relatively [10].

$$y(n) = \sum_{-n}^{n} x(v)h(n - v). \tag{9}$$

Where $x(v)$-Image1 and $h(n - v)$-Image 2(Shifted). From equation (9), a correlation is calculated between the statistical parameter values from Average Information method and reference statistical parameters of the healthy lung images, which are then given to image classifier for lung cancer diagnosis.

2.4. Image Classifier

Image classification investigates the numerical properties of different images includes and composes information into classifications. It is a two stage process that is *preparing* and *testing*. At first amid preparing stage, common picture components are isolated which has particular clarification that makes instructional order class. In the consecutive testing stage, these feature-space partitions are used to classify image features. Neural Network [11, 12] is the approach utilized as an image classifier in this work for lung cancer conclusion. The different values obtained for various measurable statistical parameters under Average Information method for cancerous and non-cancerous microscopic lung images overlaps, which settle on it hard to take choice whether picture is tainted or not, henceforth Neural Network as a picture classifier is utilized as a leader for lung cancer determination. Essentially input-output sets which for this situation are the parameter esteems acquired through the calculation and the coveted output is the training information given to ANN to construct network for speculation to analyze new unseen instances of cancer, which was absent in training information. Few parameter values for cancerous and non-cancerous lung images goes past the calculated range, for which ANN takes choices for lung cancer conclusion.

2.5. Standard Statistical Method [13]

Analysis of variance (ANOVA) [14, 15] is a collection of statistical models used to analyze the differences among group means and their associated procedures (such as “variation” among and between groups), developed by statistician and evolutionary biologist Ronald Fisher. In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes the t-test to more than two groups. ANOVA’s are useful for comparing (testing) three or more means (groups or variables) for statistical significance.

3. ALGORITHM

The algorithm of proposed work is realized through MATLAB simulation software utilizing the factual figuring and entangled investigation. It can work on biomedical pictures effectively by utilizing the biomedical toolbox associated with it. The steps of the algorithm as follows

Step 1. Microscopic lung image as the input image and pre-verified from the Physicians and radiological experts.

Step 2. Images differentiated into noncancerous and cancerous lung images from experts.

Step 3. Gray scaling, Resizing, denoising and enhancement are the preprocessing steps.

Step 4. Selection of statistical parameters under Average Information technique.

Step 5. Implementation of statistical parameters like Entropy, Mean, Standard Deviation, Variance and MSE on lung images.

Table 1. Statistical Parameter Range for Cancerous Lung Images

Average Information Parameters	Minimum to maximum range for cancerous lung	Average value of Range	Value for cancerous lung from graph	Value for noncancerous lung from graph
Mean	97 to 123	110	215.506	218.189
Standard Deviation	50 to 71	60.50	47.752	29.3785
Mean Square Error	55 to 262	108.50	228.958	245.856
Variance	2.25×10^3 to 4.84×10^3	3.54×10^3	2.25×10^3	8.17×10^2
Entropy	7.43 to 7.965	7.697	6.174	6.481

Step 6. Calculating statistical range for each parameter.

Step 7. Correlating test image and reference image parameters.

Step 8. A comparative investigation for cancerous and non-cancerous lung images by mean of statistical parameters through ANN as an image classifier.

Step 9. Finally lung cancer analysis and diagnosis.

4. RESULTS AND DISCUSSIONS

In this paper the random data is statistically analyzed, which is obtained from random patterns of lung cancer cases. Measurements include a discrete arrangement of information that is characterized by statistical parameters such as Entropy, Mean, Variance Standard Deviation and MSE. The average information technique including the above statistical parameters is applied over predetermined cancer infected lung microscopic images. With these figuring, particular scopes of each average information statistical parameters has been distinguished for the investigation and analysis of lung cancer. By applying these statistical parameters over 323 microscopic images for number of iterations in real time, the range is calculated for each parameter for lung cancer images. If the value of a particular image lies in that range, it is identified as the infected lung image. In this way each statistical parameter is applied over a particular image to get the range. Not all the parameters will give the values which will lie in that particular range, hence in this case the decision is made by Neural Network. It is one of the image classifier methods that first identify the parameters which lie in the calculated range for that particular image and takes the decision for lung cancer diagnosis.

4.1. Statistical Parameter Range

The statistical parameter range calculated for each parameter is shown in Table 1.

4.2. Parameter Analysis for Lung Images

Next thing is to analyse individual parameter response to both cancerous and non cancerous. This will help to understand the impact of that particular parameter for cancerous and noncancerous lung image images. The investigation of the significant number of parameters can be seen from as measurable from statistical response of the graph. Figures 3 to 7, which shows the actual response of 05 statistical parameters for cancerous and noncancerous lung images based on Average information method. Graphical analysis over 25 images has been shown for each parameter.

It can be seen from the discrete graph that is from Figs. 3 to 7, lesser the overlap of the points for cancerous and non-cancerous lung images, better is the usefulness of the parameter for lung cancer investigation. Standard Deviation and Variance has less overlapping points for cancerous and noncancerous lung images as compared to the other parameters. Almost all the parameters have shown good response to most of the images.

Tables 2 and 3 show calculations of parameter values for particular of cancerous and non-cancerous microscopic lung images. At the point when these computations are completed by applying over high

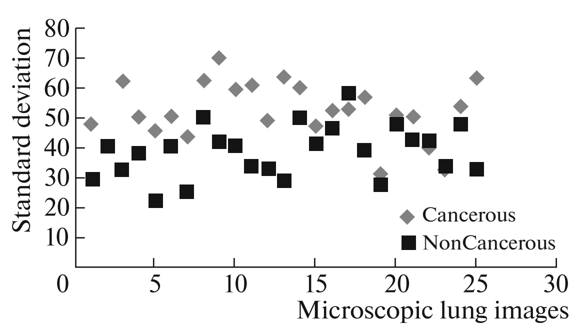

Fig. 3. Statistical Response of Standard Deviation for Cancerous and Non-Cancerous Lung Images.

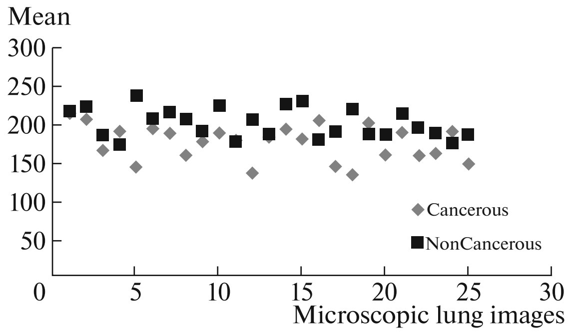

Fig. 4. Statistical Response of Mean for Cancerous and Non-Cancerous Lung Images.

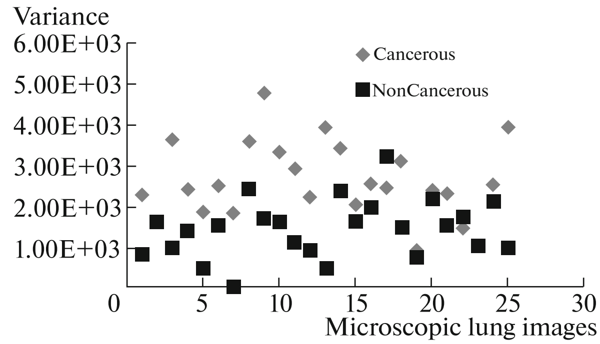

Fig. 5. Statistical Response of Variance for Cancerous and Non-Cancerous Lung Images.

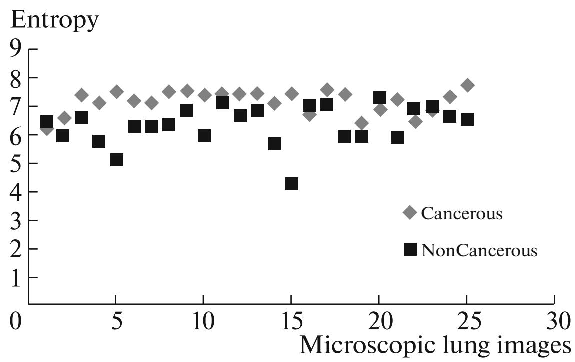

Fig. 6. Statistical Response of Entropy for Cancerous and Non-Cancerous Lung Images.

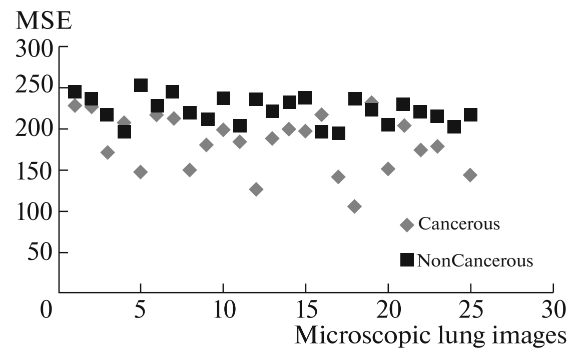

Fig. 7. Statistical Response of MSE for Cancerous and Non-Cancerous Lung Images.

data base, a range for all parameters under Average Information strategy is acquired. This range helps to distinguish between cancerous and non-cancerous lung images. In spite of the fact that it is difficult as it looks since a portion of the parameter values overlaps and is by all accounts comparable for both cancerous and non-cancerous lung pictures, subsequently this disarray is overcome by Artificial Neural Network which prepare and test the pictures for number of iterations.

4.3. Lung Cancer Diagnosis by ANN

In ANN, ADA- BOOST classifier is used. It is combination of two parts, one is simple weak classifier and other part is boosting. The first part attempts to uncover the preeminent threshold in one of the data dimensions to divide the data into two classes that is – 1 and 1. The boosting part calls the classifier iteratively, after every classification step it changes the weights of miss-classified examples creating a surge of

Table 2. Statistical Parameter values for Cancerous Lung Images

Average Information Parameters	Cancer Image1	Cancer Image2	Cancer Image3	Cancer Image4	Cancer Image5
Mean	186.783	132.90	159.83	169.28	140.52
Standard Deviation	32.68	48.554	52.813	51.21	43.69
Mean Square Error	220.78	118.89	162.88	179.72	136.92
Variance	1.024×10^3	2.308×10^3	2.426×10^3	2.465×10^3	1.841×10^3
Entropy	5.96	7.51	7.56	7.48	7.47

Table 3. Statistical Parameter values for Noncancerous Lung Images

Average Information Parameters	Non cancerous Image1	Non cancerous Image 2	Non cancerous Image 3	Non cancerous Image 4	Non cancerous Image 5
Mean	187.36	222.52	217.89	158.44	186.78
Standard Deviation	40.08	30.05	36.75	40.03	45.91
Mean Square Error	235.92	244.05	176.21	228.7	199.01
Variance	1.567×10^3	866.20	1.121×10^3	1.540×10^3	2.072×10^3
Entropy	6.12	6.39	7.00	6.24	7.28

Table 4. Accuracy of statistical Parameters for Cancerous Lung images

Sr no.	Statistical Parameters	Accuracy (%)
1	Standard. deviation	44.80
2	Variance	47.06
3	Mean	37.10
4	Entropy	39.00
5	Mean Square Error	44.34

Table 5. Overall Accuracy of the Statistical Parameters

Sr. No.	Statistical Parameters	Accuracy (%)
1	Standard. deviation	62.23
2	Variance	63.78
3	Mean	56.96
4	Entropy	58.20
5	Mean Square Error	61.92

"weak classifiers" which behaves similar to a "strong classifier."

The advantage of using ANN is that it provides an equal importance to all the parameters that are combines, hence Artificial Neural Network is applied, trained and tested for more images which can be observed for Fig. 8. That shows the graph of ANN performance, which analyzes total set accuracy versus number of trained images. It is observed that the set accuracy increases with increase in image database. The result says that it works perfectly as an image classifier and automatically provides lung diagnosis for every test image passed through the algorithm.

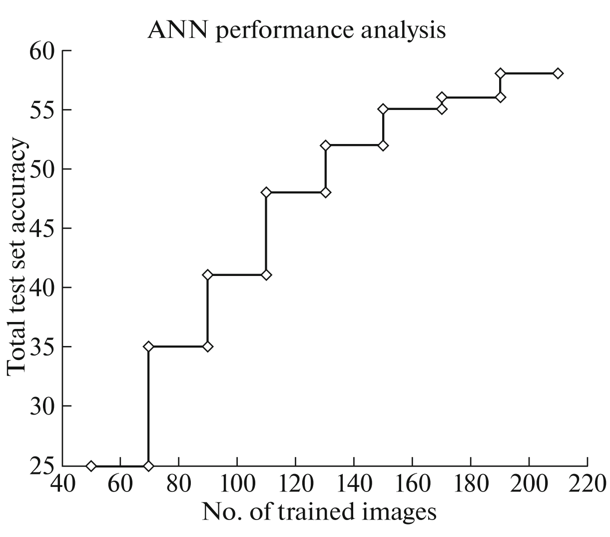

Fig. 8. Graph of ANN Performance. Statistical Response of MSE for Cancerous and Non-Cancerous Lung Images.

4.4. Accuracy of the Statistical Parameters

From Table 4, the exactness and accuracy of each statistical parameter is computed for the cancerous lung pictures which show that Standard deviation, Variance and MSE having good response for cancerous lung images.

In addition, the overall accuracy that is for both cancerous and noncancerous lung picture of each parameter is shown in Table 5 and Figs. 9 and 10, which shows that response is above 55%. It is observed that every parameter assumes an imperative part in lung cancer analysis and diagnosis. The accuracy of the Average Information technique is computed with the ability to distinguish and identify the cancerous picture accurately. The accuracy is observed to be 68.42%.

The graphs shown in Fig. 11a, b are plot for index level versus statistical parameters, gives an idea regarding varieties in statistical parameter index level as indicated according to cancerous and non-cancerous microscopic lung images. One can undoubtedly separate the microscopic images as malignant and noncancerous by cancerous and non-cancerous by observing present chart. With subjective examination charts has its own effect on lung cancer determination. Run time diagrams demonstrate the effect of Average Information parameters on lung cancer determination. Experimental results likewise show about measurable parameters, which are conveyed by ANN for conclusion making.

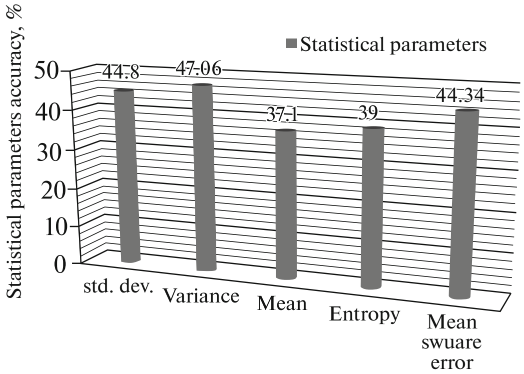

Fig. 9. Statistical Parameter Accuracy for Cancerous Lung.

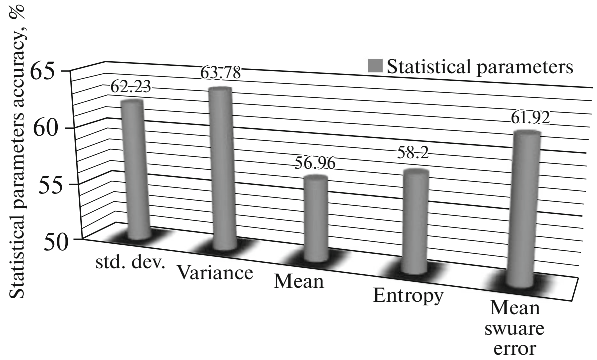

Fig. 10. Overall Statistical Parameter Accuracy.

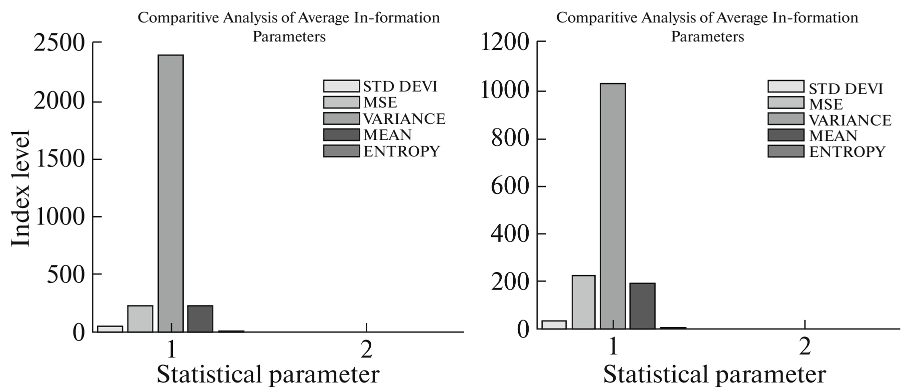

Fig. 11. Plot for index level versus statistical parameters (a): comparative analysis graph for cancerous lung, (b) comparative analysis graph for non-cancerous lung.

4.5. Results of ANOVA

In proposed system 5 groups are considered according to used parameters. ANOVA is applied over proposed system and found important calculations as follows:

Total sum of squares (TSS) = 66050543;

Sum of squares between the groups (SSB) = 5.68E+07;

Sum of squares with in the groups (SSW) = 9.25E+06;

F ratio=SSB/SSW;

F (4, 45) = 69.1, p < .05(p = significance factor);

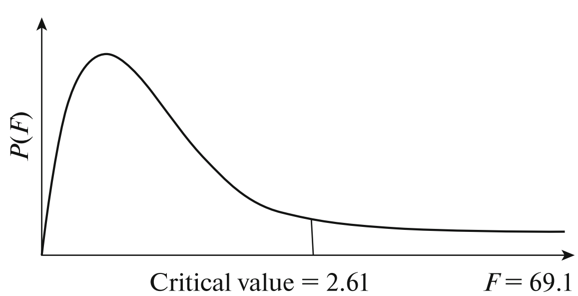

Fig. 12. Critical Value Calculation on F distribution.

Critical value = **2.61 (**approximately according to F-Distribution table for F (4, 45));

F (4, 45) is relative frequency;

F test value > Critical value, which can be observed from Fig. 12, i.e. 69.1 >2.61, hence the proposed method successfully rejects null hypothesis.

5. CONCLUSIONS

Among various average information parameters, selective parameters are recognized for lung cancer investigation and diagnosis. For determination of parameters, iteration method over predetermined lung cancer microscopic images is utilized. These parameters are tested and checked over a database of 323 microscopic lung pictures including cancerous and non-cancerous microscopic lung images utilizing image processing techniques with MATLAB. Correlation attempts to correlate the statistical parameters and find similarities between test images and reference images. Artificial Neural Network acting as an image classifier shows important role in decision making, whether current image is cancerous or non-cancerous. Furthermore, it is observed that each of the measurable statistic parameters assumes an imperative part in lung cancer determination. The overall exactness of proposed system in terms of accuracy is 56 to 63% for cancer investigation. The accuracy of the presented technique figured is 68.42% which is ascertained on the basis of number of pictures are analyzed and diagnosed accurately. The results achieved in the proposed system appear about the enhanced exactness with number of trained images, which put forward that ANN functions admirably as an image classifier for this robust technique. One of the statistical methods, ANOVA is successfully applied and executed with rejection to null hypothesis. Proposed strategy is working satisfactorily and can likewise relate with which could be a half breed mix of scientific, measurable, basic parameters enhancing the execution and precision of the proposed calculation. In any case, doubtlessly this strategy is one of the significant progressive developments towards the therapeutic research field for lung cancer investigation and analysis.

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