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Hybrid SVM for Automatic Detection of Tuberculosis

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Abstract: ***TB (Tuberculosis) is a major health threat in many regions of the world, according to the World Health Organisation (WHO). This disease caused by a type of bacteria known as Koch bacillus. When it is left undiagnosed and untreated, the patients rate increases exponentially. The major cause of this increase unreliable, slow conventional diagnosing methods and the cost of the treatment. Even after many research and development many new techniques is being developed like New Acid Amplification Technology (NAT) but still they produces false positive result and that was one of the main reason lead to the emerging of the automatic system. The most important element of the system is that there is very low rate of inaccuracy due to the human intervention and also the variants of the slide analysis. In order to the reduce all this burden of disease, a new system is being developed to automatically detect the TB from a X-ray image. This system is basically designed to behave as a second opinion consultant. In the proposed system the most recent machine learning algorithm is being used with the new feature extraction method so to classify the sample image as active TB or not. The most recent development in machine learning is the deep learning method in which Convolution Neural Network is the main heart of the system and Half cut reduction methodology also being used for the extraction of feature in which weights of the neuron are being taken as one of the feature other than SURF (Speeded Up Robust Feature) and as a classifier SVM (Support Vector Machine) is used to screen the query image as TB positive or TB negative.***

Keywords: Automated system, Tuberculosis, Convolution Neural Network, Half Cut Reduction Methodology, Support Vector Machine

I. INTRODUCTION

Tuberculosis is reported as the second leading cause of death by the survey of WHO (World Health Organisation) in 2015[1].The world has become waging a war against the TB for thousands of year. TB can affect many part of the body but it mainly affect the lungs, which is the main focus area. The complicated nature and long duration of treatment brings with substantial opportunity of the cost this lead to the loss of the economic stability of the community, so the only best method to get rid of the imbalance of the health as well as the economy is the accurate and rapid diagnosis. Mainly there are two types of specimens they are Sputum and Chest Radiography[2,3]. Using sputum diagnosing two types of stain are being used they are Ziehl-Neelsen (ZN) and Auramine as the researchers stain the sputum and capture the image using high definition cameras, the peculiarity of these stains are they emphasis the bacilli from other bacteria and background, then using different methodologies the system is completed out. But the main disadvantage of using this specimen is that it takes a long time for the diagnosing and also it requires special equipped labs to do, so as to prevent the researchers from affecting the dieses due to the sputum. Whereas in Chest X-ray lungs image is taken and the using computer-aided Diagnosis (CAD) identification of lung diseases is done similarly many methodologies is also in cooperated to found out the diseases. The advantage of this method is that it takes very less time compared to the sputum and also the risk factor of affecting dieses is also very less. So in the project X-ray image is taken as the main content for the automatic detection of the dieses.

The main motive of the project is to develop a human like analyzing, visual system in the medical sector as an application of computer Vision. Here perfect artifact recognition is done in order to develop the automatic system. Computer Vision has proven to be successful in many part of the fields like Android Eyes - Object Recognition, Image panoramas,Image watermarking, Global robot localization, Face detection ,Optical Character Recognition Manufacturing Quality Control ,Content-Based Image Indexing etc. This was the one of the main reason to use the Computer Vision in the project. The following section deals with the basic idea, which is the base of the proposed system that leads to the successful completion of the system.

Deep learning is the new area in the Machine Learning which moved with the main motive of achieving the original goal:

Artificial Intelligence. Deep learning is the method of learning multiple levels of representation to make a sense of data's like image, text etc. Due to the bottleneck that found in the Artificial Neural Network lead to development of the Deep learning . In combination with speed issues, ANNs fell out of favour in practical machine learning and simpler models such as support vector machines (SVMs) became the popular choice of the field in the 1990s and 2000s. The term "deep learning" gained traction in the mid-2000s after a publication by Geoffrey Hinton and Ruslan Salakhutdinov showed how a many-layered feed forward neural network could be effectively pre-trained one layer at a time, treating each layer in turn as an unsupervised restricted Boltzmann machine, then using supervised back propagation for fine-tuning[4,5]. Currently, it has been shown that deep learning architectures in the form of convolutional neural networks have been best performing; however, these are more widely used in computer vision

Dimension Reduction

In machine learning and statistics, dimensionality reduction or dimension reduction is the process of reducing the number of random variables under consideration, and can be divided into feature selection and feature extraction. Advances in hardware have also been an important enabling factor for the renewed interest of deep learning. In particular, powerful graphics processing units (GPUs) are highly suited for the kind of number crunching, matrix/vector math involved in machine learning

Feature extraction

Feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be very redundant then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input.

Image Classification

Contextual image classification, a topic of pattern recognition in computer vision, is an approach of classification based on contextual information in images. "Contextual" means this approach is focusing on the relationship of the nearby pixels, which is also called neighbourhood. The goal of this approach is to classify the images by using the contextual information.

II. PROPOSED SYSTEM

The system mainly contains different blocks they are Pre-processing, Dimension Reduction, Convolution Neural Network and Support Vector Machine. This combined to together to form the complete system. Each block has its own task to do as to obtain a reliable output. Since the aim is to develop an automated system so here mainly deep learning is used in which Convolution neural network is selected due to its own advantage that enhance the accuracy of the output. Similarly a half cut reduction method is implemented which also have its own peculiarity so as to extract a feature which is weight in the project other than the Speeded Up robust Feature. All this together form a automatic system for the screening of the tuberculosis.

Block Diagram

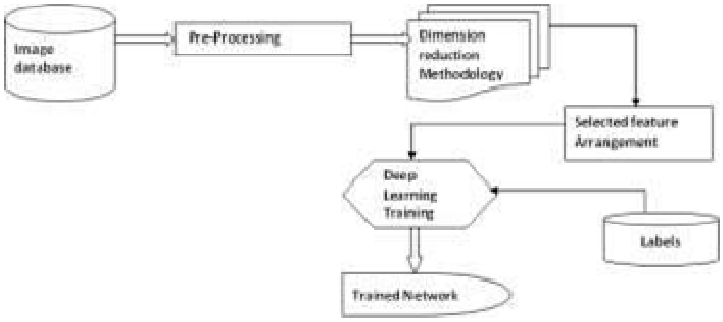

Fig.1 System Overview on training process by Deep learning

Block Explanation

The overview of this system as shown in figure.1 is explained below

Module –I: Database Collection and Arrangement

In this section the database for various type objects are collected from different portal and arranged for further proceeding.

Module-II: Pre- Processing Unit

In this section the images from collected database are pre-processed by resizing the image and histogram equalization is done to normalize so that the training priority will be provided in equal phase

Module-III: Dimension Reduction methodology

In order to make the neural network training in a more optimized way the features are selected to reduce its size.

Module-IV: Feature Arrangement

In this module the significant features are taken from the whole dataset by means of suitable feature extraction process/ algorithm.

Module-V: Deep Machine Learning- Training Sequence

This module will get all the features from the previous modules and train by itself. Through this process the neural network will unsupervisingly learn deep information about various objects and develop a trained network by mapping the input with Labels given. Till this module the explanation is about figure 1. In following section the detail explanation of the each module is given with relevant figures and equations.

Deep Learning

Deep learning is a set of algorithms in machine learning that attempt to model high-level abstractions in data by using model architectures composed of multiple non-linear transformations. Deep learning is part of a broader family of machine learning methods based on learning representations of data. Deep learning algorithms are based on distributed representations, a concept used in machine learning. The underlying assumption behind distributed representations is that observed data is generated by the interactions of many different factors on different levels. Deep learning adds the assumption that these factors are organized into multiple levels, corresponding to different levels of abstraction or composition. Varying numbers of layers and layer sizes can be used to provide different amounts of abstraction. Deep learning algorithms in particular exploit this idea of hierarchical explanatory factors. Different concepts are learned from other concepts, with the more abstract, higher level

concepts being learned from the lower level ones. These architectures are often constructed with a greedy layer-by-layer method that models this idea.

Convolutional neural networks

Convolution Neural Network consist of mainly three layers which are convolution layer, sub-sampling layer and output layer. The main focus of project is convolution layer and sub-sampling layer. The CNN aricheture allows CNN to take advantage of the 2D structure of input data.[10,11,12] In the convolution layer the input image is convolved with a mask which is a weight vector of 2D matrix. The output of the convolution is summed with a adjustable parameter called bias. Then an activation function is applied to obtain an output plane. The output obtained is called as feature map, since gives the visual feature in the pixel location of the feature. More than one feature map is produced and it connected to the exactly one plane in the sub-sampling layer. Sub-sampling layer has the same number of layers as convolution layer in the preceding layer. In the sub - sampling layer plane is divided into 2D into non- overlapping blocks. Then sum of the 4 pixels of 2X2 block is calculated and multiplied by the weight factor and again added with the bias term. The resultantant is passed through the activation function to produce the output of 2X2 block. It is clearly seen that the sub-sampling layer reduces the dimension of the input image. Again the sub-sampling layer is associated with one or more planes in the next convolution layer and so on.

Dimension Reduction Strategy

When the huge amount of dataset is involved in the processing there is a important need of dedicated GPU (Graphical Processing Unit) or high performance system. So there is a need of dimension reduction for the fast processing of the system. Selection of strong Features lead to the better performance of the classification. Usually training of the Artifical Neural Network (ANN) in which input is mapped to target. Mapping is called as the training of the Neural Network. Basically ANN consist of three layers they are Input Layer (IL), Hidden Layer(HL) and Output Layer(OL). Dimension of the input as well as output layer depends on the input and target values.

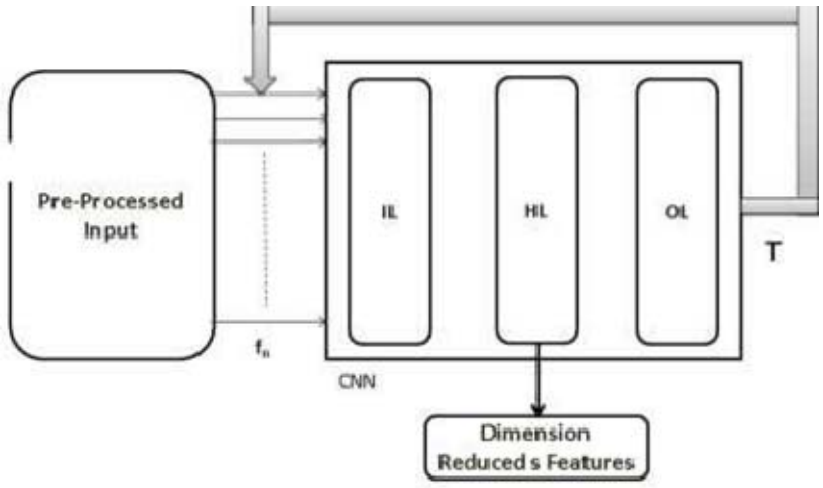

Figure 2: Strategy of Feature Dimension Reduction

HL Requires two constrains to be defined (1) no of layers to stack the training process (2) no of neurons for each layer, which gives the multilayered neural network. In-order to reduce the dimension of the features the hidden layer stage of layer are assigned in such a way that each hidden layer with reduced neurons from its predecessors. Suppose the no of features from DBN is 2^x then the $layer-1$ of HL with 2^x $neurons$, $layer-2$ of HL with 2^{x-1} $neurons$, $layer-3$ of HL with 2^{x-2} $neurons$ etc. The neuron reduction for each layers will result in reducing the feature input to the next stage.

Speeded Up Robust Features

SURF[13] is comprised of a feature detector based on a Gaussian second derivative mask and feature descriptor that relies on local Haar wavelet response. The SURF method (Speeded Up Robust Features) is a fast and robust algorithm for local,

similarity invariant representation and comparison of images. It is basically consist of two steps SURF detection and SURF description.Following is the steps that is involved in finding the SURF feature.

1. Form the scale-space response by convolving the source image using DoH filters with different σ
2. Search for local maxima across neighbouring pixels and adjacent scales within different octaves
3. Interpolate the location of each local maxima found
4. For each point of interest, return x, y, σ, the DoH magnitude, and the Laplacian's sign
5. determining an orientation for each feature, by convolving pixels in its neighbourhood with the horizontal and the vertical Haar wavelet filters.
6. The longest vector is the dominant orientation. Second longest is ignored.

Half Cut Reduction Methodology

Half Cut Reduction Method is a process of extracting information from the Neural Network in the middle of its learning i.e.; hidden layer. Here in the project process of taking weights as an feature from the middle of the hidden layer.

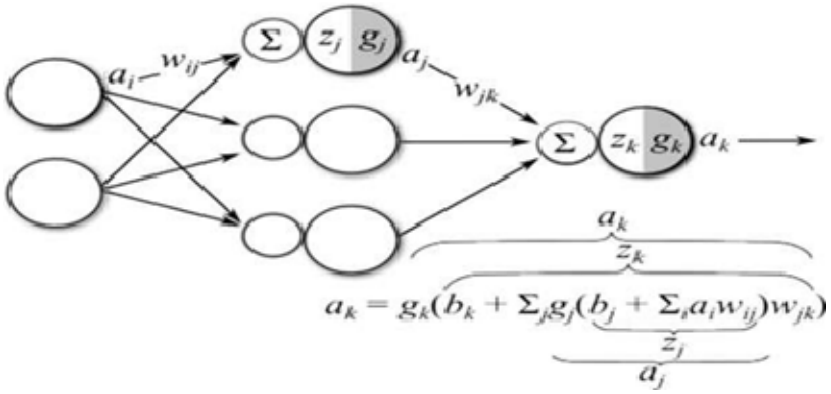

Fig 3 Half Cut Reduction Methodology

The signal from the input layer a_i are multiplied by a set weight vector w_{ij} connecting the input layer to the hidden layer. The weighted signal are added and combined with bias. The calculation forms the preactive signal $z_j = b_j + \sum a_i w_{ij}$ which is for hidden layer. The preactive signal is then transformed by the activation function g_j to form a feed forward activation signal. In similar manner the hidden layer activation signal a_j to form network output a_k. The output is then compared with the desired target value t_k, and the error is calculated.

Training of the network involves the minimization of the error that a network makes. The choice of the error function is the sum of the square of the difference between the target and output value of the network..

$$E=\frac{1}{2}\sum_{k\in K}(a_k - t_k)^2$$

Output layer connection weight, w_{ik}:

Since the output layer parameter directly affect the value of the error function

$$\frac{\partial E}{\partial w_{jk}} = (a_k - t_k)\frac{\partial}{\partial w_{jk}}(a_k - t_k)$$

$$\frac{\partial E}{\partial w_{jk}} = (a_k - t_k)\frac{\partial}{\partial w_{jk}} g_k(z_k)$$

$$\frac{\partial E}{\partial w_{jk}} = (a_k - t_k)\frac{\partial}{\partial w_{jk}} g'_k(z_k)\frac{\partial}{\partial w_{jk}} z_k$$

Since $z_j = b_j + \sum a_i(z_j) w_{ij}$ and $\frac{\partial z_k}{\partial w_{jk}} = g_j(z_j) = a_j$

$$\frac{\partial E}{\partial w_{jk}} = (a_k - t_k) g_k'(z_k) a_j$$

$$\delta_k = (a_k - t_k)\, g_k'(z_k)$$

Put

$$\frac{\partial E}{\partial w_{jk}} = \delta_{kaj}$$

The above equation can be used to interpret each weight contribute to the error signal by weighing the error signal by the magnitude of the output activation from the hidden layer associated with each weight.

Multiclass SVM Classifier

SVM (Support Vector Machine) is a type of learning models which recognize and analyze the data in supervised manner. SVM is mainly used for the applications where classification requires. Usually SVM classifier classifies data, only into two categories. Since this application requires more than two categories of classification to diagnose the TB , a multi-class SVM is in-planted into this work. The multi-class SVM is inherited from the SVM which is created with simple strategy i.e each dataset features and labels are trained by SVM and its model is noted such as

$$Model_1 = SVM_{training}(Dataset_1, Label_1)$$

Where,$Dataset_1$ contains all the possible features collections for same type of disease and $Label_1$ has its corresponding labels, ,Which can be generalized as

$$Model_i = SVM_{training}(Dataset_i, Label_i)$$

ivary from 1 to m. m stands for no of diseases/ classes During the process of classification all these trained Models are tested with the test sets. A Model which shows the minimum error is considered to be its belongings.

Operational Procedure

1. First the collection of all datasets(images) consist of TB affected X-ray image and normal X-ray image of lungs.
2. To process these images in a common system first, it has to be normalization. So the pre-processing procedure is handled which includes resizing of image and histogram equalization.
3. These normalized images are given to CNN stage as an input and deep features extracted .
4. In-order to select the strong features and to reduce the dimension of the features, a dimension reduction strategy is handled using a half cut module.

III. Result And Discussion

Implementation process

Datasets for training and testing

During the implementation process number of datasets is being collected and by means of this dataset the performance of the algorithm is tested. The databases are 48 X-ray images of lungs

A. 24TB affected X-ray lungs images
B. 24TB normal X-ray lungs images

Training Process

The training process involves with CNN stages of about 2 which 100 iteration of epoch each. The momentum is kept non variable with alpha value be 1. The arrangement of neurons will follow the pattern of 2 power n-1(where n is number of neurons) in the hidden layer, here as input following is being initialized.

First convolution layer with out-map and kernel size=6,5

First Subsampling Layer with scale=2

Second convolution layer with out-map and kernel size=12,5

Second Subsampling Layer with scale=2

Number of Epoch=100

Batch size=2

Alpha =1

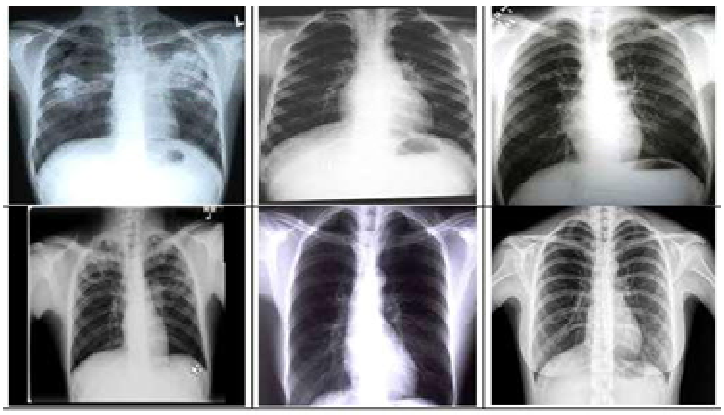

Figure 8: Sample objects for positive TB X-ray images

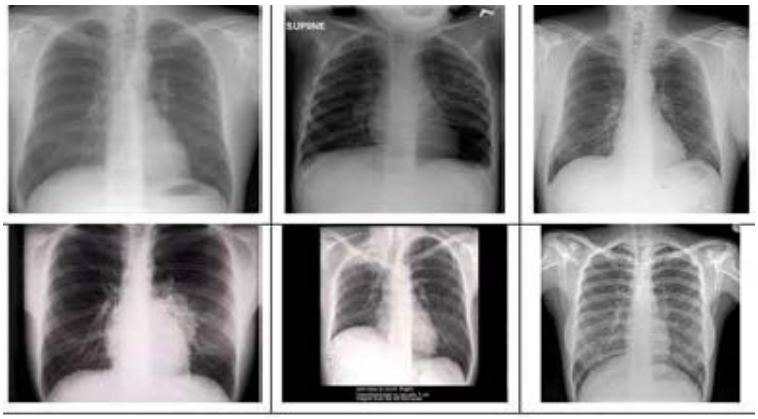

Figure 9: Sample objects for negative TB X-ray images

Table 1: Comparison of Accuracy, Sensitivity and Rank correlation of different techniques.

TECHNIQUES	ACCURACY	SENSITIVITY	KENDALL CORRELATION
Multi-layer Perceptron Neural Network(MLPNN)	74.61%	72.30%	0.62
Multi-layer Perceptron(MLP)	81.04%	80.04%	0.62
Support Vector Machine	83.42%	78.23%	0.65
Convolution Neural Network with Support Vector Machine(CNNSVM)	86.65%	83.89%	0.69

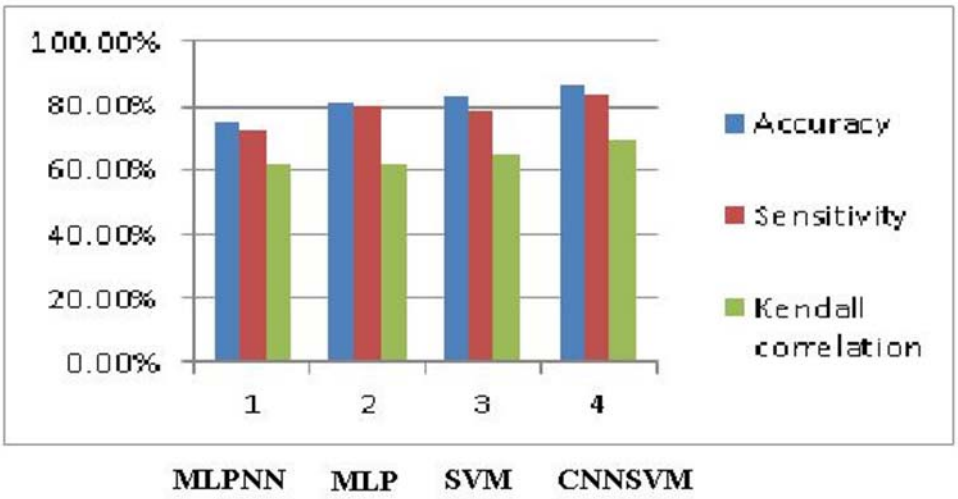

Figure 10: Performance chart of the system

$$\tau(r_1, r_2) = 1 - 2\sum_{ij} \frac{\delta\{r_1(i,j) \neq r_2(i,j)\}}{n(n-1)}$$

In the training process of this the data collected is about 48 X-ray images in which 26 X-ray images are positive TB and 24 X-ray images are negative TB as shown in fig 4 and 5. The above equation gives the Kendall τ correlation[14] in which r_1 and r_2 stands for features that are being found out using the algorithm and the features that are being already assigned which are the correct features which are being collected after the several different images being tested. of the image which is under process. Kendall correlation is used in order to find the weightage of the features which are effective. n stands for no of datasets used for recognition. Specially, the obtain accuracy is of approx. 86.65% as shown in table-1, the average Kendall rank correlation of 0.69. This result shows that the method is robust against other techniques

IV. CONCLUSION

In this Project the CNN based object recognition system was developed to overcome the problem of finding or recognizing variable structured objects. Also a flexible dimension reduction strategy is handled which will reduce the computation power requirement. This algorithm is checked by using 48 X-ray images with 24 samples of positive X-ray images and 24 negative X-ray images . The time consumption of these systems is high but the error and performance of the network . From this analysis it is sure that the efficiency of the systems stabilizes by increasing the number of datasets. Though this measurement the system shows up to 86.64% of accuracy .From this whole research work the problem which still needs attention is, more training time taken by the algorithm due to insufficient computation capability happens by rapidly increasing the number of datasets. This is the problem definition, which needs future enhancement

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References

1. World Health Organization, “Global tuberculosis report,” Rep.WHO/HTM/TB/2012.6,2015.
2. V. Kumar, A. K. Abbas, and J. C. Aster, \Robbins basic pathology," Philadelphia, PA,USA: Saunders, 2012.
3. Stefan Jaeger, Alexandros Karargyris, Sema Candemir, Les Folio, Jenifer Siegelman, Fiona Callaghan,Zhiyun Xue, Kannappan Palaniappan, Rahul K. Singh, Sameer Antani, George Thoma, Yi-Xiang Wang, Pu-Xuan Lu, and Clement J.McDonald,” Automatic Tuberculosis Screening Using Chest Radiographs,” IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 33, NO. 2, pp. 233-245, FEBRUARY 2014.
4. Arel, Itamar, Derek C. Rose, and Thomas P. Karnowski. "Deep machine learning-a new frontier in artificial intelligence research [research frontier]."Computational Intelligence Magazine, IEEE 5.4 (2010): 13-18.
5. Yu, Jincheng, et al. "A vision-based robotic grasping system using deep learning for 3D object recognition and pose estimation." Robotics and Biomimetics (ROBIO), 2013 IEEE International Conference on. IEEE, 2013.
6. Ans, Bernard, Jeanny Hérault, and Christian Jutten. "Adaptive neural architectures: detection of primitives." Proc. of COGNITIVA’85 (1985): 593-597.
7. M. K. Osman, F. Ahmad, Z. Saad, M.Y Mashor, H .Jaafar “ A Genetic Algorithm Neural Network Approch for mycobacterian tuberculosis for Ziehl-Neelsen stained tissue slide image”2010 10th International Conference on Intelligent Systems Design and Applications.pp 1229-1234
8. M. K. Osman, M. Y. Mashor, H. Jaafar, “ Tuberculosis Bacilli Detection in Ziehl-Neelsen- Stained Tissue using Affine Moment Invariants and Extreme Learning Machine”, 2011 IEEE 7th International Colloquium on Signal Processing and its Applications.pp 232-236
9. W R CRUM, DPhil, T HARTKENS, PhD and D L G HILL, PhD, Non-rigid image registration: theory and practice, The British Journal of Radiology, 77 (2004), pp S140–S153
10. Cosmin Cernazanu-Glavan, Stefan Holban, “Segmentation of bone structure in X-ray images using convolutional neural network”, Advances in Electrical and Computer Engineering, Volume xx, Number x, 20xx, pp 1-7.
11. Shih-Chung B. Lo, Shyh-Liang A. Lou, Jyh-Shyan Lin, Matthew T. Freedman, Minze V. Chien, and Seong K. Mun, “Artificial Convolution Neural Network Techniques and Applications for Lung Nodule Detection,”IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 14, NO. 4, DECEMBER 1995,pp 711-718.
12. Qing Li, Weidong Cai, Xiaogang Wang, Yun Zhou, David Dagan Feng, and Mei Chen” Medical Image Classification \with Convolutional Neural Network,” 2014 13th International Conference on Control, Automation, Robotics & Vision Marina Bay Sands, Singapore, 10-12th December 2014 (ICARCV 2014),pp 844-848
13. H. Bay, T. Tuytelaars, and L. Van Gool: SURF: Speeded Up Robust Features (2003), pp. 1-13
14. G.P.Sillito: The distribution of kendall status coefficient of rank correlation in ranking containg tie.Biometrika, Vol.34, No.1/2.(Jan.,1947),pp.36-40

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