International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

Detection of Tuberculosis in Chest X-rays using U-Net Architecture

S.Usha Kiruthika, S. Kanaga Suba Raja, V. Balaji, C.J.Raman, S. S. L. Durai Arumugam

Abstract: *x-rays are the most commonly performed which are costly diagnostic imaging tests ordered by physicians. Here we are proposing an artificial intelligence system that can reliably separate normal from abnormal would be invaluable in addressing the problem of undiagnosed disease and the lack of radiologists in low-resource settings. The aim of this study is to develop and validate a deep learning system to detect chest x-ray abnormalities and hence detect Tuberculosis (TB) and to provide a tool for Computer Aided Diagnosis (CAD).In this paper by trying to explore existing systems of Image Processing and Deep learning architectures, we are trying to achieve radiologist level detection as well as lower False Negative detection of TB by using ensemble datasets and algorithms. The prototype of a WebApp is created and can be checked on https://parth-patel12.github.io where one can upload the chest x-ray which give probabilities of the chest x-ray to be normal or TB affected.*

***Keywords** : Autism, Generative adversarial network, Convolutional Neural Networks, Artificial Neural Network, Tuberculosis, Computer Aided Diagnosis.*

I. INTRODUCTION

Before the finish of 2015, tuberculosis (TB) was assessed to taint 1/3 of mankind. Consistently roughly 2 million individuals pass on of this illness, making it the second driving irresistible enemy of grown-up around the world, as indicated by World Health Organization (WHO). In normal, a TB understanding taints 15 others, a large number of them are relatives, at the time before the patient is effectively treated. The salary of the tainted decays by 30%, of whom are the most defenseless and the least fortunate, and as a result among the contaminated the destitution cycle sustains. Early conclusion and maintainable treatment can stop the spread and diminish the TB rate. Chest radiography is these days the essential examination instrument on TB for worker restorative examination and routine determination,

Revised Manuscript Received on November 30, 2019.
* Correspondence Author
S. Usha Kiruthika* Assistant Professor, Department of Computer Science and Engineering, SRM Institute of Science and Technology, Kattankulathur Campus. usha.kiruthika@gmail.com
Dr. S.Kanaga Suba Raja, Easwari Engineering College, Chennai, India, skanagasubaraja@gmail.com
Mr.V.Balaji, Department of Information Technology, Easwari Engineering College, Chennai, India. balaji.iniyan@gmail.com
Mr. S. S. L. Durai Arumugam, Assistant Professor, Easwari Engineering College, Chennai, Tamil Nadu, India.
Dr. C.J.Raman , Associate Professor , Department of Information Technology, St. Joseph's College of Engineering, Chennai, Tamil Nadu, India.

even in the well-prepared medicinal Center where skin test and blood test are accessible. Doctors, as a rule, settle on a choice on TB cases for the most part dependent on radiologic discoveries, joined with statistic/clinical information.

In any case, in numerous nations, the shortage of assets, for example, the radiologist regularly drives the mass screening on a chest radiograph is excessively requesting on the nations' medicinal services framework. To determine the previously mentioned, PC helped/PC helped analysis was recently proposed to diminish the remaining burden on radiologists and improve perusing proficiency. Researchers have developed an extensive interest for deep learning due to the development of new variants of CNN's and the advent of efficient parallel solvers optimized for modern GPUs. Deep learning generally refers to machine learning models which roughly stimulates neurons such as Convolutional Neural Networks (CNN) that represent low-level and high-level notion obtained from raw data (e.g. images). Recent studies indicate that the generic descriptors or the features obtained from CNN are extremely useful in object detection as well as recognition, and are currently the leading technology. Deep learning models give significant results when used over a large set of Data. But, In the field of medicine, such a large set of data is still not available. Even though the field of medicine has few restrictions on the labelled data side, research can be found that explores the possibilities of using Deep Learning for computer-aided diagnosis. However, we have not seen any studies that use generic, non-medical training datasets in order to address the task of medical imaging. We are also unaware of any deep neural architecture models for the specific task of pathology detection in chest radiographs. In this work, we intend to examine the capabilities of deep learning approaches for pathology detection in chest x-ray data. We also explore the classification of normal versus tuberculosis (TB) affected which is an important screening task. In our experiments, we explore the possibility to use convolutional neural networks (CNN) that are learned from ImageNet, a large scale nonmedical image database, for performing Computer Aided Diagnosis of the medical image analysis of x-rays.

A. Tuberculosis (TB)

Tuberculosis (TB) is brought about by microscopic organisms (Mycobacterium tuberculosis) that regularly influence the lungs. Tuberculosis is reparable and preventable. TB is spread from individual to individual through the air.At the point when individuals with lung TB hack, sniffle or spit, they impel the TB germs into the air. An individual needs to breathe in just a couple of these germs to wind up contaminated.

Around one-fourth of the total populace has idle TB, which implies individuals have been contaminated by TB microorganisms however are not (yet) sick with the sickness and can't transmit the malady.

Individuals tainted with TB microbes have a 5– 15% lifetime danger of becoming sick with TB. In any case, people with traded off invulnerable frameworks, for example, individuals living with HIV, ailing health or diabetes, or individuals who use tobacco, have a lot higher danger of becoming sick.Over 95% of cases and passings are in creating nations. Individuals who are tainted with HIV are 20 to multiple times bound to create dynamic TB (see TB and HIV area underneath). The danger of dynamic TB is likewise more noteworthy in people experiencing different conditions that debilitate the safe framework. One million kids (0– 14 years old) became sick with TB, and 230 000 youngsters (counting kids with HIV related TB) kicked the bucket from the sickness in 2017.Tobacco use enormously expands the danger of TB ailment and demise. 7.9% of TB cases worldwide are inferable from smoking. TB happens in all aspects of the world. In 2017, the biggest number of new TB cases happened in the South-East Asia and Western Pacific areas, with 62% of new cases, trailed by the African district, with 25% of new cases. In 2017, 87% of new TB cases happened in the 30 high TB trouble nations. Eight nations represented 66% of the new TB cases: India, China, Philippines, Indonesia, Pakistan, Bangladesh, South Africa and Nigeria

If we could determine the nature and where exactly the pneumonia has occurred, we could solve the problems faced by doctors which leads to late reports and time complexity. To ensure this, we must develop a system in which there are lots of training sets of person's history and background check and most importantly a CXR image. This would do the trick and hence by the power of ANN we could determine the effects of the person and hence solve the problem. This paper aims to modify the present review system in the health care. There are a large number of datasets in the present systems, so it becomes quite tedious for the client to read through all the data. We try to demonstrate a system with more insights on the patients' health. This would be much more entertaining and user friendly.

B. Concept of ANN

ANN is a major concept for data analysis and provides a building block of how an artificial brain could work. Consider a system, where we need to determine the difference between an apple and a bomb. Now, for this we need the basic features of what exactly is the difference. These features then get trained by the model to determine and hence releases insights on how this is an apple or a bomb. Similarly, in our day to day scenarios we come across various applications which helps in detecting objects and getting to know the insights. These insights provide a way to solve various problems and then includes true cut accuracy which leads to greater performance in less time. The ANN consists of 3 layers: input, hidden and output. The input layer provides input in any data format, the hidden layer includes various functions to train the input data and the output layer produces the output.

C. Dataset

The dataset is organized into 3 folders (train, test, val) and contains subfolders for each image category (Tuberculosis/Normal). There are 5,863 X-Ray images (JPEG) and 2 categories (Tuberculosis/Normal).

D. Transfer Learning

The transfer learning model is a model that is reused to define a specific task from the starting point. Apart from ML, it uses a pre-trained model that has been used for something else and it quickly starts the processes by a new task format with the previous model performance. It is more effective performance wise. Below are the figures that help us understand transfer learning in a more effective way.

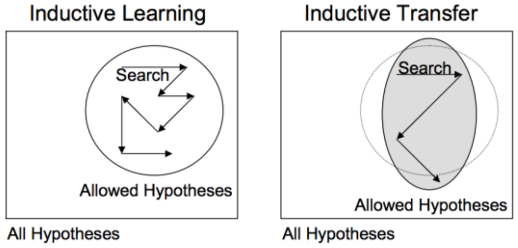


Figure 1.1: Depiction of Inductive Transfer Learning.

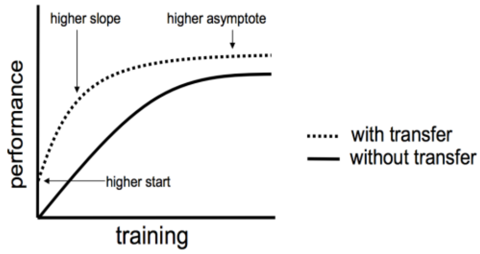


Figure 1.2: Performance graph : with and without Transfer Learning.

II. LITERATURE REVIEW

Tuberculosis (TB) is a threatening irresistible ailment and is a noteworthy wellbeing risk in the greater part of the areas in the world. The vast majority of the indicative techniques were created in the only remaining century which are still being used. expending and for the most part temperamental. Chest radiography is utilized as the most widely recognized strategy for screening of substantial populace. The achievement of this strategy relies upon the experience and the understanding ability of the radiologists. Computer Aided Diagnosis (CAD) model can be utilized to defeat this issue and can quicken the procedure of dynamic case finding. There is an extensive development as of late, in the field of deep learning, which permits the characterization of amazingly heterogeneous pictures. Convolutional neural systems (CNN), a profound deep learning system has picked up notoriety because of its capacity to learn mid and abnormal state X-ray. In this work different CNN models are utilized which orders the chest radiographs into TB positive and TB negative classes. The execution of the framework is estimated on two freely accessible datasets: Shenzhen chest X-beam set and Montgomery County chest X-beam set (MC).

The proposed Computer Aided Diagnosis model for TB screening accomplishes exactness over 80%, which is similar to the execution of radiologists.

In this work, authors have utilized a Convolutional Neural Network (CNN), Deep learning architecture for making a Computer Aided Diagnosis (CAD) model. When contrasted with different approaches, the significant advantage of utilizing deep learning is the feature extraction process. With a deep system, VGGNet gives a satisfactory outcome with the dataset utilized. The use of growth techniques to build the dataset is definitely not a smart thought on account of restorative pictures, as the model adapts some misleading examples which cause a reduction in the precision of the model. The strategy for exchange learning, in which a model pre-prepared on some dataset is utilized on some other dataset is valuable if the dataset on which the model will be utilized is as of now known to the model, as for this situation, the ImageNet does not have any class of radiographs, along these lines, we got unsuitable outcome. The precision of the model can be additionally improved by expanding the chest radiograph dataset, with an increasing number of pictures more features will be found out by the model.[1] The semantic division is an essential instrument for visual scene understanding and a huge extent of vulnerability is required for basic leadership. Its responsibility is a straightforward system which can foresee pixel-wise class names with an extent of model vulnerability. The paper achieves this by Monte Carlo investigating with dropout at test time to make a back appointment of pixel class names. In like manner, the creators exhibit that showing vulnerability improves division execution by 2-3% over different front line structures, for instance, SegNet, FCN and Dilation Network, with no additional parametrisation. The creators furthermore get an immense improvement in execution for littler datasets where showing vulnerability is dynamically effective. We benchmark Bayesian SegNet on the indoor total scene, Understanding and outdoors CamVid driving scenes datasets. Creators showed.SegNet, a profound convolutional arrange to engineer for the semantic division. The standard motivation driving SegNet was the need to design a profitable structure for road and indoor scene understanding which is compelling both to the extent memory and computational time. We analyzed SegNet and pondered it with other crucial varieties to reveal the practical trade-offs drew in with arranging structures for division, particularly getting ready time, memory versus accuracy. Those structures which store the encoder orchestrates feature maps in full perform best anyway eat up more memory in the midst of determination time. SegNet, on the other hand, is logically profitable since it just stores the most extreme pooling records of the segment maps and uses them in its decoder framework to achieve extraordinary execution. On generous and without a doubt comprehended datasets SegNet performs seriously, achieving high scores for road scene understanding. Through and through the learning of significant division structures is a harder test and we need to see more consideration paid to this fundamental issue.[2] This paper includes a very detailed analysis of image processing which determines the cloud region present in the lungs. Moreover, the model uses an algorithm known as Otsu Thresholding which determines the healthy lung region to the total region. This is then fed to filter and hence gets the minimum of the ratio. This minimum region is where the clouds are present. When looked closely, the dataset uses CXR images of only 10,000 images and has an accuracy of 80%. The future insights given are very much understanding and provides a relationship between the healthy to the total region.

Moreover, the method adapts various image processing techniques from OpenCV and uses a wide range of equalizers. This is then used for inner sharpness and gradients of the image where the image shows some blurred areas which consist of clouds. This in fact provides a better understanding of how the image can be preprocessed and the clear idea indicates a pattern as to where the clouds might be present. The early model suggested the less accurate value, whereas this improved version provides a better look into the image.

The major drawback of this image is, it is not capable of rendering complex image structures and hence decreases its performance. As the dataset is really small compared to other large dataset, it fails to take up values beyond 10,000 and hence this indicates underfitting of the model. The testing set also have no insights about how the data could affect in future[3]. This model detects radiology level pneumonia with the help of a 121-layer CNN. The base paper gives us a closer look on the model detection which provides different layers to create a CNN. These layers are basically based on the different features of the images and gives us a clear idea about the different lines and curves to solve the problem.

The paper provides a singular approach of CNN and uses performance gradient techniques to make the model more and more precise. A clear idea provides simple classification of pneumonia and non-pneumonia. The 121 Layers provide stability to the model and gives insights based on how radiology level is determined. It includes various boosting techniques which provides definitive approach. The researchers have built up a 121 layer CNN which identifies pneumonia from frontal-see chest X-beam pictures. The method outperforms radiologists. We likewise demonstrate that a basic augmentation of our calculation to identify numerous maladies outflanks the past best in class on ChestX-ray14, the biggest openly accessible chest X-ray dataset. With robotization at the dimension of specialists, we trust that this innovation can improve medicinal services conveyance[4].This particular paper depicts the Chest X Ray using multi-label classification. The classification is based on extraction of features which uses fine-grained learning model. This offers a variety of pretrained models which are classified as CNN architectures. This paper demonstrates the effectiveness using multi-label loss function (MSML). These provide a clear idea about different types of model used to determine the multi-label classification. It also uses multi-label learning loss and bilinear polling to determine the methodologies involved in the classification of pneumonia chest images. These provide a different set of approach which results in greater performance issues. The dataset contains 70% for training ,10% of validation and 20% of testing. These good splits up provide a clear picture of how to represent a particular dataset and hence provides greater relationships. However, the main drawback is the interdependencies on the datasets. The reason behind is the case of overfitting where the training data is more and also doesn't hold good in these situations. However, the idea behind is of greater effect and hence determines a good way of detecting using labels.[5]

III. PROPOSED SYSTEM

While the existing systems obtains accuracies up to 78% on chest radiographs. They have some drawbacks like the high false positive rate, lower accuracy if we consider it to commercialize or make it to the market. The existing systems are purely a research and they have not tried to make it open to use it for public. By open means the research is not simplified enough so that the doctors can use that as an assistant. In other words there is no public interface that can be used by both doctors and patients to get a general overview about that x-rays. Here we have tried to overcome those issues by creating a web interface so that it could reach to the masses. However, the developed system is the prototype version.

The architecture flow of the proposed system consists of 6 major components.

- Inputs
- Segmentation
- Up-sampling with U-net
- Data Augmentation
- Predictions
- Web Interface/Web-app

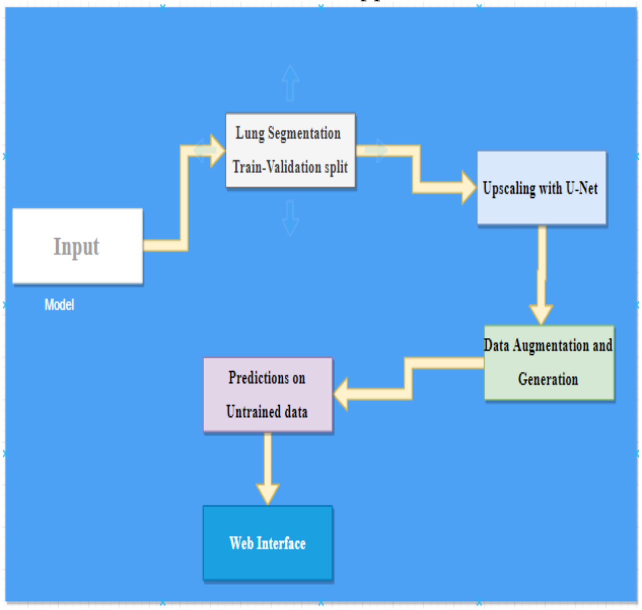


Figure 2.1 Flow of the proposed system

We realize that the publicly labeled X-rays are exceptionally less in numbers and consequently there is a solid requirement for information increase. There is an additional requirement for quicker and lung segmentation. Here we propose the different architecture design of a CNN, called U-Net which can perform both augmentations and segmentation in a quick and proficient way. Additionally, it can yield high goals picture from low goals inputs. The U-Net architecture is based upon the Fully Convolutional Network and adjusted such that it yields better segmentation in restorative imaging. Contrasted with FCN-8, the two fundamental differences are (1) U-net is symmetric and (2) It skips associations between the down sampling way and the up sampling way by applying a concatenation rather than an addition. These skip associations mean to give nearby data to the worldwide data while up sampling. In view of its symmetry, the system has countless maps in the up sampling way, which permits to exchange data. By examination, the essential FCN engineering just had a number of classes include maps in its up sampling way.

A. U-NET Architecture

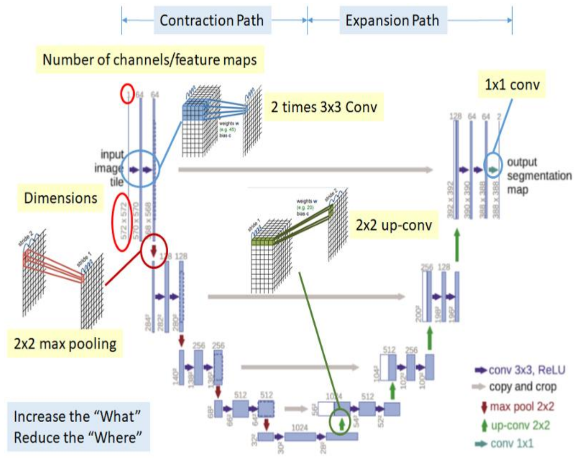
The U-Net is quite useful for segmentation of medical images due to its symmetric shape, which is not the same as other FCN architectures.

U-Net architecture is divided into 3 parts:

1 : The down-sampling /contraction path

2 : Bottleneck

3 : The up-sampling /expansion path



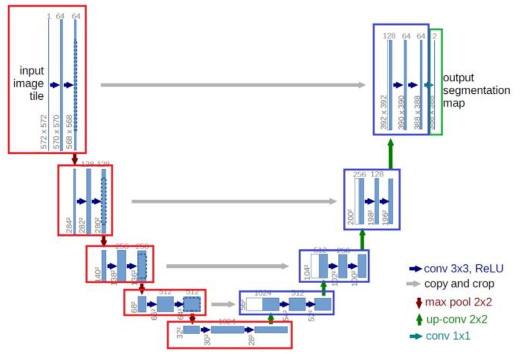


Fig. 1. U-net architecture (example for 32x32 pixels in the lowest resolution). Each blue box corresponds to a multi-channel feature map. The number of channels is denoted on top of the box. The x-y-size is provided at the lower left edge of the box. White boxes represent copied feature maps. The arrows denote the different operations.

A. Working Principle

Down-sampling /Contracting path

The contracting path is composed of 4 blocks. Each block is composed of

- 3x3 Convolution Layer + activation function (with batch normalization)
- 3x3 Convolution Layer + activation function (with batch normalization)
- 2x2 Max Pooling

Note that the quantity of highlight maps duplicates at each pooling, beginning with 64 include maps for the primary square, 128 for the second, etc. The reason for this contracting way is to catch the setting of the information picture so as to have the capacity to do division. This course relevant data will at that point be transferred to the up-sampling way by methods for skip associations.

Retrieval Number: A4834119119/2019©BEIESP
DOI: 10.35940/ijitee.A4834.119119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

IV. WEB INTERFACE

The web interface works as follows:

- Upload a chest x-ray that is to be diagnosed.
- The pre-trained model gets loaded in the backend.
- The uploaded images is passed to the model.
- The model is run on the x-ray uploaded.
- Predictions are propagated back to the front-end.

When the user uploads any x-ray image, the web app passes it to the pretrained model which has already been loaded into the server. The model then is run on the input image, which is a chest x-ray. The entire model is run using JavaScript framework, which is a deep learning library that enables deep learning in browser.Once the results are obtained, the probabilities of the input being a case of Tuberculosis or normal/healthy chest is propagated back to the front end where we can see the results. The web app simplifies the computer aided diagnosis commonly known as CAD. Which is meant to assist doctors so that they can focus on curing more number of patients.

V. PERFORMANCE EVALUATION

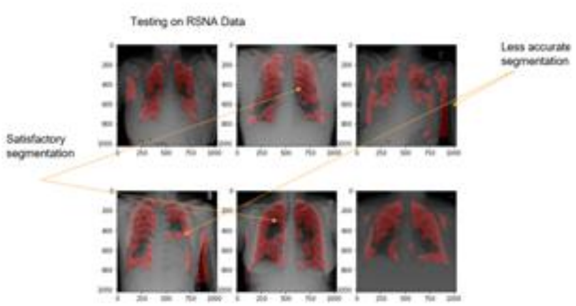
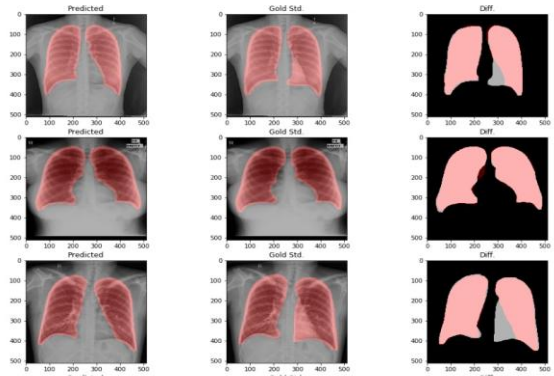


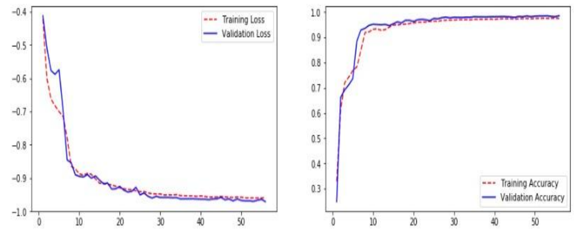
Fig.5.1. Testing on RSNA data

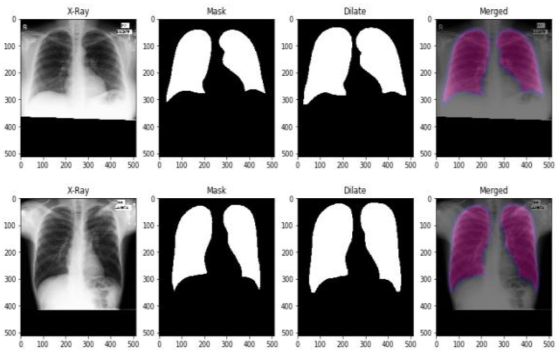
Fig.5.2. Validation \loss & Accuracy Flow Graph

```
Epoch 00035: val_loss improved from -0.76223 to -0.77873, saving model to cxr_reg_weights.b
est.hdf5
Epoch 36/70
6/6 [==============================] - 5s 834ms/step - loss: -0.7569 - true_positive_rate:
0.8715 - binary_accuracy: 0.8555 - val_loss: -0.7605 - val_true_positive_rate: 0.8492 - val
_binary_accuracy: 0.8654
```




```
<matplotlib.legend.Legend at 0x7fdd108e2e10>
```






```
Epoch 35/56
302/302 [==============================] - 62s 205ms/step - loss: -0.9477 - dice_coef: 0.94
77 - binary_accuracy: 0.9681 - val_loss: -0.9407 - val_dice_coef: 0.9407 - val_binary_accur
acy: 0.9603
```

The Kanade Lucas Tomasi (KLT) Algorithm for face detection gives the accuracy of 80.3% whereas Viola-Jones Algorithm for face detection gives the accuracy of 93%[16]. The Eigen Face Algorithm for Face Recognition gives the accuracy of 79% whereas the Local Binary Pattern (LBP)[19] Algorithm for Face Recognition gives the accuracy of 97.9%. Since the performance of Viola-Jones and LBP Algorithm is higher, we have used this for face detection and face recognition. [16][19]

VI. CONCLUSION

Thus, a smart assistant has been developed for Asperser's In this extensive research about computer aided diagnosis and detection of tuberculosis (TB) directly from chest x-rays we were able to achieve the accuracy of about 81% and segmentation accuracy of more than 98%.

We were also able to create an user friendly web interface which can take a chest x-ray as an Input which is an e-copy of an x-ray image or we can say it as a digital x-ray. And the web app displays the probabilities of a x-ray having tuberculosis (TB) or not. This solution can simplify the process of diagnosis and can reduce the burden from the radiologists.

The solution is developed not to replace the doctors but to assist them. As we have seen the cases of false diagnosis or two doctors having different viewpoints for the same chest x-ray. This analysis can help them in reducing such unfortunate cases. The research will assist the doctors and medicine practitioners to taking care before making any decision or can give a basic idea about the x-ray.South East Asia contributes more than 66% of tuberculosis reports worldwide and India alone had more than 10 million TB cases in a year. Most of which remain un diagnoses due to the shortage of radiology experts. The tool can be used in remotest area and the doctor can see the analysis from any part of the country. In short the tool can help in early stage diagnosis of Tuberculosis.

REFERENCES

1. World Health Organization. Global tuberculosis control: epidemiology, strategy, financing: WHO report 2009. World Health Organization, 2009.
2. Jankharia, Govindji R. "Commentary-radiology in India: the next decade." The Indian journal of radiology & imaging 18, no. 3 (2008): 189.
3. Jaeger, Stefan, Alexandros Karargyris, Sema Candemir, Les Folio, Jenifer Siegelman, Fiona Callaghan, Zhiyun Xue et al. "Automatic tuberculosis screening using chest radiographs." IEEE transactions on medical imaging 33, no. 2 (2013): 233-245.
4. Dye, Christopher. "Global epidemiology of tuberculosis." The Lancet 367, no. 9514 (2006): 938-940.
5. Doi, Kunio. "Computer-aided diagnosis in medical imaging: historical review, current status and future potential." Computerized medical imaging and graphics 31, no. 4-5 (2007): 198-211.
6. Xu, Yan, Tao Mo, Qiwei Feng, Peilin Zhong, Maode Lai, I. Eric, and Chao Chang. "Deep learning of feature representation with multiple instance learning for medical image analysis." In 2014 IEEE international conference on acoustics, speech and signal processing (ICASSP), pp. 1626-1630. IEEE, 2014.
7. Tan, Jen Hong, U. Rajendra Acharya, Collin Tan, K. Thomas Abraham, and Choo Min Lim. "Computer-assisted diagnosis of tuberculosis: a first order statistical approach to chest radiograph." Journal of medical systems 36, no. 5 (2012): 2751-2759.
8. Badrinarayanan, Vijay, Alex Kendall, and Roberto Cipolla. "Segnet: A deep convolutional encoder-decoder architecture for image segmentation." IEEE transactions on pattern analysis and machine intelligence 39, no. 12 (2017): 2481-2495.
9. Litjens, Geert, Thijs Kooi, Babak Ehteshami Bejnordi, Arnaud Arindra Adiyoso Setio, Francesco Ciompi, Mohsen Ghafoorian, Jeroen Awm Van Der Laak, Bram Van Ginneken, and Clara I. Sánchez. "A survey on deep learning in medical image analysis." Medical image analysis 42 (2017): 60-88.
10. Cao, Yu, Chang Liu, Benyuan Liu, Maria J. Brunette, Ning Zhang, Tong Sun, Peifeng Zhang et al. "Improving tuberculosis diagnostics using deep learning and mobile health technologies among resource-poor and marginalized communities." In 2016 IEEE First International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE), pp. 274-281. IEEE, 2016.
11. Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." In International Conference on Medical image computing and computer-assisted intervention, pp. 234-241. Springer, Cham, 2015.

AUTHORS PROFILE

Dr.S.Usha Kiruthika is currently working as an Assistant Professor in the Department of Computer Science and Engineering in SRM Institute of Science and Technology, Kattankulathur Campus. She has completed her Ph.D at Anna University and she has many publications to her credit. Her areas of interest include artificial intelligence and deep learning.

Dr. S. Kanaga Suba Raja is working as an Associate Professor in Easwari Engineering College. He obtained his Ph.D degree in Computer Science in 2013 from Manonmaniam Sundaranar University, Tirunelveli. He has about 14 years of teaching and research experience. He has successfully guided many graduate and under-graduate students for their research projects. He has several papers published in International journals and conferences to his credit. His current research interests are Wireless Body Area Networks, Ad hoc and Sensor Networks and Mobile and Ubiquitous Computing.

Mr.V.Balaji is currently working as an Associate Professor in the Department of Information Technology in Easwari Engineering College, Chennai. He is pursuing research in Anna University, Chennai. He has about 17 years of teaching experience He has many publications to his credit. His areas of interest include artificial intelligence, Wireless sensor Networks and deep learning.

Dr.C.J.Raman is working as an Associate Professor in the Department of Information Technology in St. Joseph's College of Engineering. He obtained his Ph.D degree from the faculty of Computer Science and Engineering in 2019 from Sathyabama Institute of Science and Technology, Chennai. He is having nearly 13 years of teaching experience on both graduate and post graduate level and has guided many students in their curriculum project work. He has published many papers in reputed International Journals. His research interests include controlling congestion with minimum delay and energy consumption in wireless sensor networks and Network Security.

Mr. S. S. L. Durai Arumugam is working as an Assistant Professor in Easwari Engineering College. He obtained his Master Degree in Software Engineering in 2013 from Anna University, Chennai. He has about 6 years of teaching and research experience. He has successfully guided many under-graduate students for their research projects. He has several papers published in International journals and conferences to his credit. His current research interests are Data Analytics, IP Networking and Deep Learning..