JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Pneumonia Detection using X-rays Image Preprocessing

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Abstract: In this research, a machine learning based self-diagnostic website is proposed and implemented for self-diagnosis. The proposed website provides major functionality, quick pneumonia diagnosis. Due to increase in chest diseases in country, it is essential to provide awareness about pneumonia. Government's attempt to decrease rate of various chest infections through implementations of different schemes and regulations. As not need much, therefore, the use of such websites can help patient's to detect there disease. This proposed website makes use of machine learning by comparing current image to a model trained with thousands of x-rays. Patient's x-ray image can be uploaded to website and further classified to normal or infected category. The proposed prototype website can be further developed into android application, accuracy can be further improved using inception v2 algorithm and this web-app can be collaborated with hospitals and doctors and live doctor-patient consult session feature can be added.

1. Introduction:

In this century, the world is prone to diseases causing high risk to lives, people have been fighting with different diseases since centuries by finding cures and vaccines of these diseases and eliminating them from the society. In today's busy life it's hard take care of ourselves so by saving time using technologies we can take care of ourselves. One of the major types of disease which the society has faced over a long time is chest infection, it one of the most tragic pandemic, Spanish flu influenza, was also caused by chest infection took 50000000 lives world-wide. Pneumonia [1-6] includes the infection of the tiny air sacs in the lungs, alveoli. In pneumonia the alveoli are filled with fluid, making breathing painful and reduce the oxygen intake. Over 2.56 million people died from pneumonia in 2017, almost victims were children below 5 years. Usually, it is diagnosed using radiological images [7-8] by physicians and determining the agents that caused disease. But sometimes frequent interactions with doctors are not possible so by using the proposed website one can easily self-assess himself.

2. Literature Survey:

In this research, we give a unique method for classifying an X-ray image on its possibility of showing pneumonia in the initial stages of the disease with three different pre-processing techniques: color-space increment, contrast increment and artificially lightening of the image. Multiple combinations of pre-processing techniques with various networks have been used. Increment in lightening was combined with contrast to incorporate feature-extraction processes. CNN approach was used to obtain feature maps of Xray images.

An x-ray is a grayscale image where the lighter areas are areas that have absorbed more radiation allowing bones to be identified. At the other extreme the areas that absorb less radiation are areas full of air, therefore, the air housed in the lungs will have its representation in the x-ray with a very dark color close to black.

Finally, between both extremes with tonal variations within the grey scale can be appreciated tissues and fluids. Pneumonia provokes in the patient that his lungs fill with pus or other fluids reducing his capacity to hold air. Regarding its interpretation in an X-ray, instead of seeing an air-filled lung with a tone close to black in all its extension, certain opacities will appear inside the lung.

The term opacity in the interpretation of x-rays is defined textually as: "any area that preferentially attenuates the x-ray beam and therefore appears opaquer than the surrounding area".

Also, role of ML and ESP becoming important nowadays in latest applications, recognition and control [11-65].

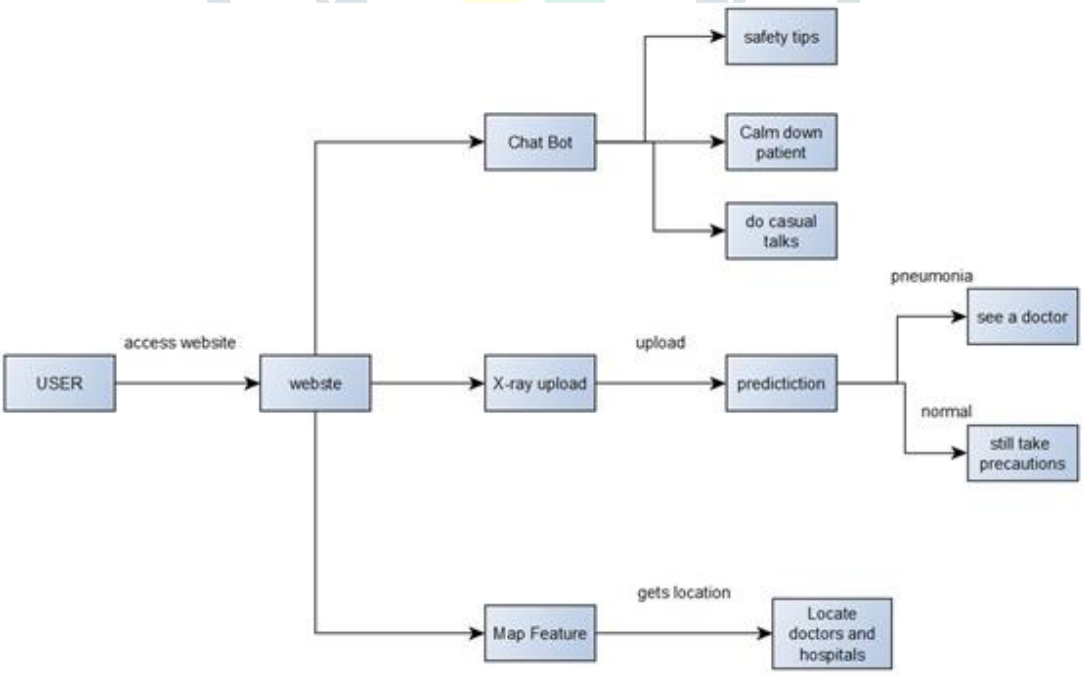

Fig.1. Complete Processing of Proposed System

3. Implementation and Design:

3A) Design Approach: After all the background research, a dataset of 5000+ jpeg chest x-ray images is selected as a base. This dataset contains both normal and pneumonia infected images.

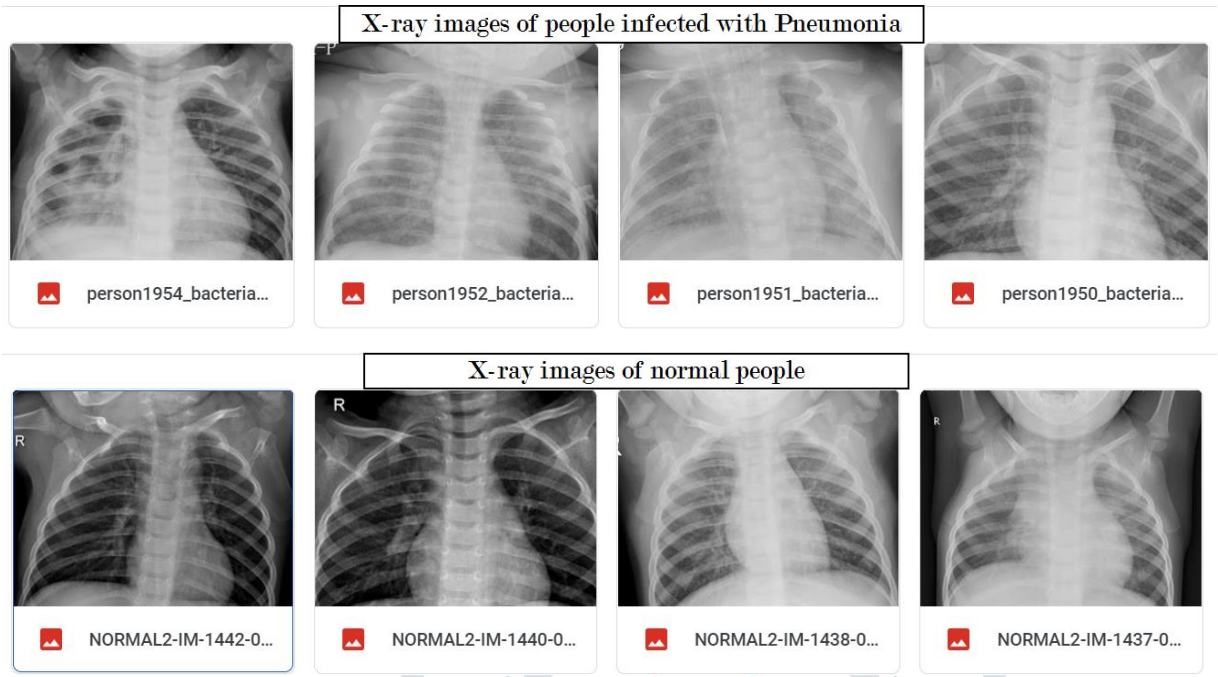

Fig.2. Typical Images with and without Pneumonia from Kaggle[9].

From the existing research it is found that best algorithm for this type of image classification is Convolution Neural Network. A brief explanation about CNN is given below.

3B) Convolutional Neural Network: Neural Network used efficiently for image recognition and classification. They are highly adept in areas like uncovering of faces, traffic signals, items apart from causing vision in self-operating cars and robots as well.

The main tasks of CNN involve-

1. Convolution
2. Non-Linearity (ReLU)
3. Pooling or Sub Sampling
4. Classification (Fully Connected Layer)

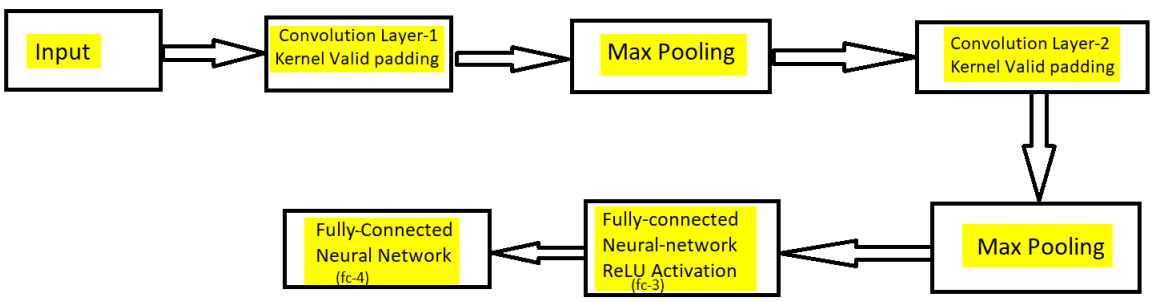

Fig.3. Typical Flow of CNN used for experimentation

3C) Convolution: The main aim of this step is the extraction of features of the input image. Convolution reads the features and works in synchronization with pixels by using small squares of input data.

Think about a 5 × 5 image with only 0 and 1 as the pixel values. The range of pixel values in grayscale images is 0 to 255.
Think about another 3 x 3 grid. This second matrix's each value is multiplied with each value of first matrix and resultant will be formed with the same size.

3D) Introducing Non-Linearity (ReLU): Rectified Linear Unit is a non-linear operation in and of itself; it is applied per pixel and replaces each negative pixel value in the feature map with 0. Its purpose is to introduce non-linearity in ConvNet since the maximum real-life data to be fed into our ConvNet is non-linear. (Convolution is a linear operation because it has element-wise matrices for multiplication and addition; as a result, ReLU-like non-linear functions must be introduced to account for non-linearity).

ReLU can be replaced with non-linear functions like "tanh" or "sigmoid," for example. However, ReLU is the most often utilised option because it consistently outperforms other options in most circumstances.

3E) The Pooling Step: Spatial pooling, also known as downsampling or subsampling, is used to reduce the dimensionality of individual feature maps while maintaining the essential data. There are various sorts of pooling in this case-

1. *Max Pooling*: It is necessary to define a spatial neighborhood (like a 2x2 window), after which the largest element of the feature corrected map within that neighborhood is selected.

2. *Average Pooling*: Instead of largest element the Average one is picked.

3. *Sum Pooling*: When the window's component sums are computed.

Max Pooling has demonstrated that it is the best.

Convolution along with ReLU operation is implemented on a rectified feature map and then Max Pooling operation is performed by using a 2×2 window.

Generally, Convolution is achieved on the output of the first Pooling layer by the second convolution layer employing six filters, leading to the generation of six feature maps as well. There are two sets of ReLU, convolution, and pooling layers. On each of these six feature maps individually, the ReLU layer is then applied. The remaining step is Max Pooling, which is carried out separately on each of the six rectified feature maps.

Synchronization among all the above layers supports the abstraction of essential features from the input images, post that non-linearity is added to the network and feature dimension is cut down thus, creating the

features equivariant to scale and translate. The output of 2nd pooling layer provides input to the Fully Connected Layer.

Further a function was defined which takes set of images and converts them into grayscale from RGB. Images are converted to single channel because they are already black in white xrays, using multi channel image cause unnecessary processing since for each channel separate convolution will happen and that is of no use.

3F) Pre-processing of image: Image preprocessing is very important to boost up results, it optimizes the training, reduce time, increase accuracy. Preprocessing include height shifting, shearing image, zooming, rotating , rescaling and many more.

3G) Uniform aspect ratio: It is crucial to ensure that all the images have the same size and width-to-length ratio also known as aspect ratio. Most of the neural network models presume a square shaped input image. While cropping the images that are not perfectly square, we usually care about the part in the center.

3H) Image Scaling: Before feeding to training process we have to ensure that all the images are of same size otherwise fitting will go out of range.

Here in this case images are rescaled to 150x150 pixels.

3I) Data augmentation: Another common pre-processing technique involves augmenting the existing data-set with perturbed versions of the existing images. Scaling, rotations and other affine transformations are typical. This is done to expose the neural network to a wide variety of variations. This makes it less likely that the neural network recognizes unwanted characteristics in the data-set.

3J) Normalizing image inputs: Ensuring that each input parameter(pixel) has an analogous data distribution is an essential step known as Data Normalization. This makes convergence quicker whilst training the network. During this process, the mean is subtracted from each pixel and dividing the result by standard deviation. The distribution of such data would be similar to a Gaussian curve centered at zero. For image inputs we want the pixel numbers to be positive, so we may perhaps choose to balance the normalized data in the range [0,1] or [0, 255]. Here we have divided each pixel in images by 255 to make it under range of 0 to 1.

3K) Shuffling: It's very important to shuffle images and its must if images in your dataset are arranged or grouped in order, if they are not shuffled the suppose during training model reads couple of images as of one type then it get overfitted with that type and starts showing 99.99 accuracy and then suddenly next type of images goes into model and this overfit model reads them as false predictions and this goes for couple of hundred times too hence model's accuracy starts tending to zero.

3L) Image augmentation: Some changes in physical appearance of images like zooming, height shifting, width shifting, rotating etcetera is done so that model does not see images as same and trained model is ready for any shape size of input image. Here in this case height is shifted by 0.2 factor randomly and zoomed by 0.2 factor.

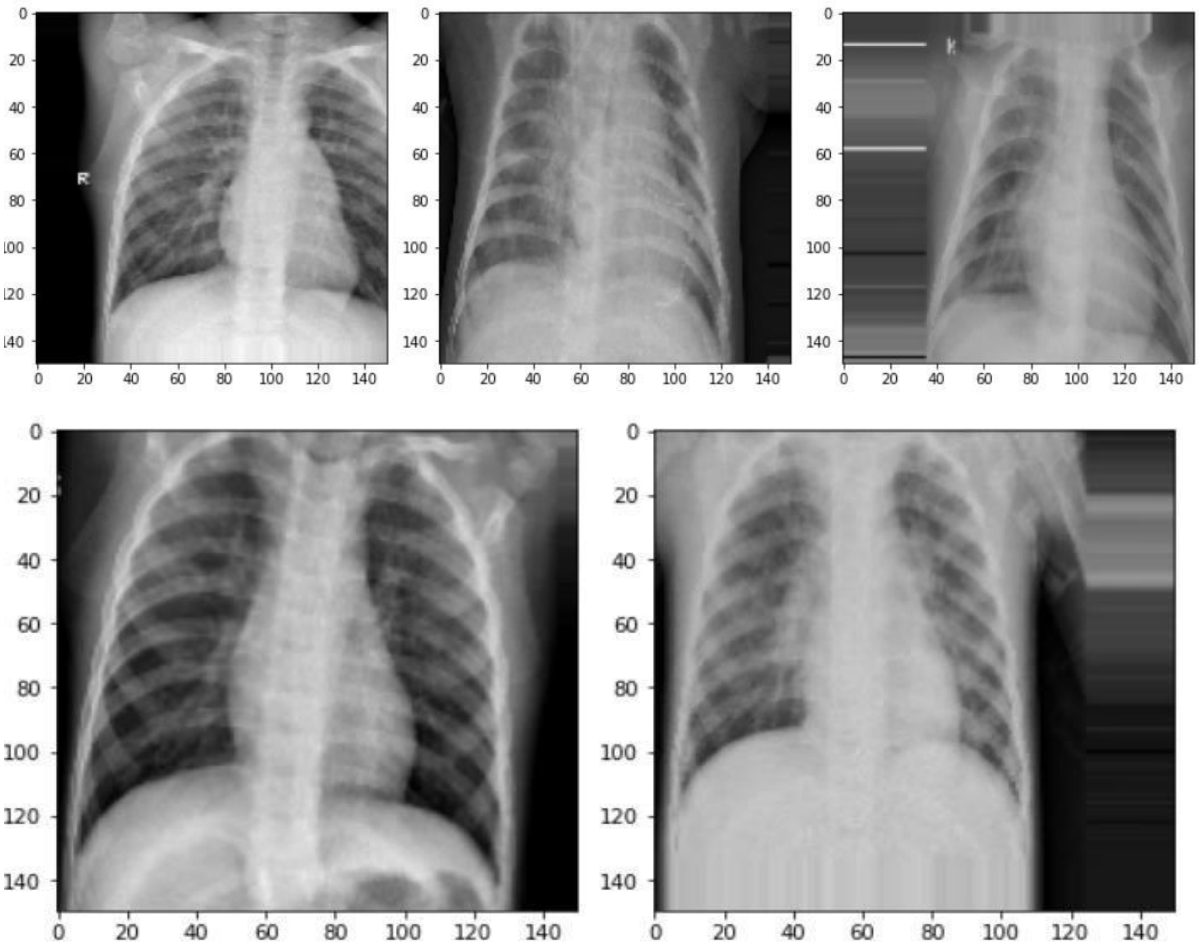

Fig.4. Images after preprocessing using tool from google colab [10]

4. Performance and Evaluation of proposed system:

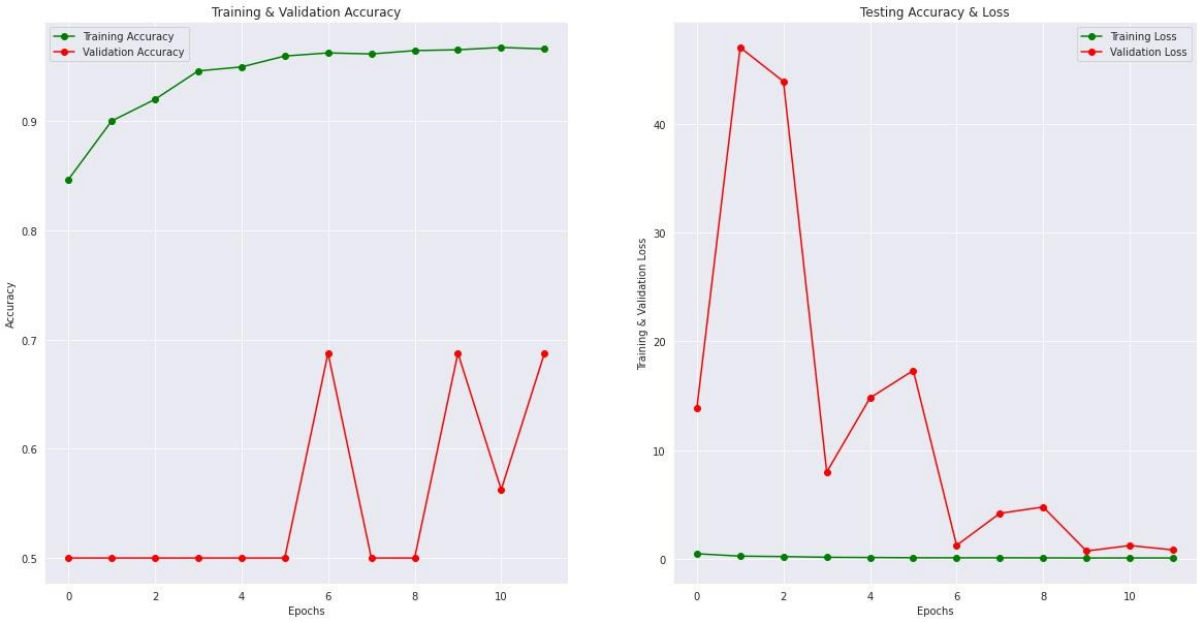

Fig.5. Validation Performance

	precision	recall	f1-score	support
Pneumonia (Class 0)	0.93	0.96	0.94	390
Normal (Class 1)	0.92	0.88	0.90	234
accuracy			0.93	624
macro avg	0.93	0.92	0.92	624
weighted avg	0.93	0.93	0.93	624

Fig.6. Analysis after Training

From the above figures, we could achieve a high Training accuracy with more than 0.85 (85%) and minimal Training loss with less than around 2%. Also, the validation loss, calculated after every epoch, equals the training loss, resulting that the model is an optimal fit.

Fig.6. shows the summary of all the factors required to assess the model. We were able to achieve a high accuracy of 0.93 or 93% with a support of 624 images.

5. *Conclusions:*

Pneumonia is the lone major infectious cause of death in children worldwide. It has killed 808694 children under the age of 5 in 2017, leading for 15% of all deaths of children under the age of five. Children can be secured from pneumonia, it can be prevented with simple mediations and treated with low-cost, low-tech medication and care. Most of the people die because pneumonia goes undetected to long time and when they knew, it already become worse and incurable. So this paper's outcome is that it will help in detecting pneumonia at early stage so that proper treatment can be given to people. As mentioned, gov. can make schemes and integrate this web app with many local labs where people can get instant x-ray and instantly their pneumonia can be checked. This will help government to track down the pneumonia cases and help them to make policies to treat patients and minimize total cases.

6. Future Scope:

The proposed paper makes use of machine learning by comparing current image to a model trained with thousands of x-rays. Patients' x-ray image can be uploaded to website and further classified to normal or infected category. As an extension to this, a map-feature of nearby clinics and quick query answering bot to calm the panics of the patients can be added. People can search nearby hospitals and clinics using map feature. A special chat bot feature to comfort people after knowing their condition, which can chat with people and give them safety tips. This proposed prototype can be further developed into android application, accuracy can be further improved using inception v2 algorithm and this web app can be collaborated with hospitals and doctors and live doctor-patient consult session feature can be added.

Acknowledgement: We are deeply thankful to Dr. R.C. Jaiswal for all the tremendous support and guidance he shared encouraging to successfully conduct and implement this research. His advice and professional acumen proved to be a valuable guidance.

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