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Smart Diagnosis Using Machine Learning

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Abstract

We discuss a plausible way for smart diagnosis. Theuse of Deep Learning in image processing can enable us to build Models to detect the presence of ailments in Diagnostic Images such as X-Ray or CT Scans performing as a diagnosis tool. These trained models can be effortlessly added into an easily accessible portal like a website or a phone application providing ease of use even for a non-practitioner. Further, we have covered a case study on how we built a Convolution Neural Network Model over a set of X-Ray Images of Lungs to determine the presence of pulmonic disease like Pneumonia using Keras framework.

Keywords:*Smart Diagnosis, Machine Learning, Deep Learning, Convolutional Neural Networks, technology*

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INTRODUCTION

Machine Learning, subset of Artificial Intelligence, is a broad area of study whose use as a technology has proliferated in the recent times due to its wide and ambitious applications. It deals with developing algorithms that can utilize a large amount of data to 'train' itself to recognize similar data without any explicit programming. These 'trained' models can predict or classify the resultant attribute of similar data. It possesses the ability to solve numerous real world problems as we can process not only textual, but moving visuals and audio too. Its current applications are widespread over domains like Computer Vision, Pattern Recognition, Language Processing, Monitoring, and Diagnosis and so on. For example, Microsoft's InnerEye, which began in 2008, is an initiative on diagnostic imaging using Machine learning [1]. Researchers of Google Brain are taking a pilot at Aravind Eye Hospital in Madurai and planning a similar one at Sankara Nethralaya Hospital to grade photos of patients' retinas via AI to detect Diabetic Retinopathy in the World's Diabetic Hotspot – India [2]. These examples clearly display prevalent research and development of AI and Machine Learning in Health Care Sector. But there are certain problems which restricts complete deployment of AI for replacement of human experts. Practitioners often argue that increment of tools in diagnosis will just augment the detection process and amalgamating the result will be a hassle [3]. Also, introduction of AI will generate contraptions that may need additional expertise to comprehend the working and produced output. The recent rise in research on AI for health diagnosis provides us plausible plan. The easy coding provides us with functional ML models which can process Diagnostic images and classify them as containing abnormality or are benign to high accuracy (up to 96%)[4]. These models are utilizing algorithms such as Support Vector Machine, Naive Bayes, Artificial Neural Networks and further derivation of these [3]. The detection by these trained models is being stated as better than bare eye human expertise [4]. Moreover, due to the flexibility of technology provided by Tensor Flow, we propose that these 'trained' models can be added to everyday use interfaces such as PhoneApplications [5]. Conclusively, this means that we could upload a photograph of a scan or X-ray image on our Android Device Application and develop an estimated report for the illness in the patient, if it exists. We are investing in a system that is extremely user friendly and provides user interface comprehensible even for non-technical crowd .This reduces the complexity of medical

diagnostic procedure aligning to time and cost restraints. To illustrate our methodology, we have implemented a Convolutional Neural Network model over X-ray images of lungs of children to detect presence of Pneumonia. CNN is efficient for Image Processing due its multi-layer model structure and was an optimum choice [6]. The model displays accuracy to certain extent. Tensor Flow Library will further enable us to add our model to a Android application. We can further construct a user friendly Interface and display result in a comprehensible format.

SMART DIAGNOSIS

Problem in Diagnosis using Machine Learning

AI has gained a lot of attention and research for health care and detection. Researchers have constructed Machine Learning models that are around 95-96% accurate in detecting diseases [4], which is statically better than how doctors detect it using their personal expertise. But these tools remain unimplemented in the actual sector probing the question on what improvement can we bring about in these ideas to make them adaptable to the current health diagnosis setup. We try to see it from the perspective of both the patient and practitioner. The factors of a diagnostic process that matter the most to a patient is - the communication of an accurate and timely explanation of their health problem which is cost and time efficient. While for the doctor, the diagnostic tool must be easy to use, reducing the complexity of diagnostic procedure without need of external technical expertise. With the availability of numerous tools, the diagnostic process has become a time consuming and costly process. Moreover, the patient, who may be a non-practitioner, may not understand the need of such a lengthy diagnostic process[3].

Solution Devised

Our plausible idea is to build a ML model which can classify diagnostic images like X Rays and CT Scans to detect presence of any disease .These models will intake labeled images of scans as input data to train itself to recognize similar images and whether they are infected or not. If trained suitably, it will be able to spot any anomaly in the given diagnostic image and give out a report depending on the kind of abnormality it witnesses. These models can be added to Mobile or Web Applications using suitable libraries, thus simplifying the process. Thus, a doctor could simply upload a Diagnostic Image of the patient to the application to get a report. This procedure would be fundamentally easy, quick and transparent which can even be apprehensive for the non-technical crowd. To test out idea, we tried to implement a basic Artificial Neural Network Model over a data of X-ray images to diagnose an illness. Hence is the case study of the methodology we followed.

CASE STUDY

Pneumonia is an infection in the lungs affecting mostly children below the age of 2 years and adults aged 65 years and older. It affects the lungs by inflaming the air sacs present there with fluid or pus, making it difficult for the patient to breathe and causing incessant coughing. [18] While it usually is not a life threatening disease, it is a major cause of child mortality in many developing countries, causing almost 2 million pediatric deaths every year [4].

Present Diagnostic Procedure of Pneumonia

Diagnosis of pneumonia is conducted by healthcare professionals by conducting thorough history and physical examination of the patient. Further a series of tests are recommended depending on the severity of symptoms and obscurity of diagnostic results. These tests range from Blood Tests, Chest X Ray imaging, Pulse Oximetry and Sputum test. If you are a patient of high risk, due to your past health history or present age and health status, further tests like CT Scans may be advised to get a better look of chest inflammation. [7]

Reducing the Need of Multiple Tests

We present the scope of detection solely using X Ray Scans in an effortless manner.

- Machine Learning Algorithms for Image Processing can enable us to classify images as malign or benign.

- The normal chest X-ray depicts clear lungs without any areas of abnormal opacification in the image. Bacterial pneumonia typically exhibits a focal lobar consolidation, whereas viral pneumonia manifests with a more diffuse ‘‘interstitial’’ pattern in both lungs. [10] These are the patterns that the ML algorithm builds on to make predictions on the test set (Figure 1).
- We will use Machine Learning and Deep Learning libraries, functions, and algorithms to build the main working algorithm for this software. We will use CNN, an abbreviation for Convolutional Neural Network, for building the framework of this software. CNN is a class of deep neural networks used for analyzing visual imagery. They are a type of multilayer perceptrons, also known as fully connected layers wherein each neuron in a layer is connected to all the neurons in the next layer [17].

Convolutional Neural Networks

Convolutional Neural Network has 4 main steps – Convolution, Max Pooling, Flattening, and Full Connection.

The convolution layer is the main building block of a convolutional neural network. Its main aim is to extract high-level features such as edges etc. from the input image. The input image is divided into a matrix of pixels. To perform the convolution operation, a kernel or filter is selected – it is a matrix having smaller pixels than that of the input image. This kernel traverses the entire image to provide us with feature maps (the output received on convolving the image with a particular filter is called a feature map) [8][9].

The next layer is the pooling layer. It is used to further reduce the spatial size of the feature map. It extracts the dominant features of the image and gets rid of the redundant parameters, thereby reducing the computational power of the network and effectively training the model. Each feature map is operated upon individually. The most common approach used in this layer is max pooling. It has a better performance as compared to average pooling since it returns the maximum value from the portion of the image covered by the feature maps [8][9].The next step is flattening wherein the matrix is flattened into a one dimensional matrix, analogous to a chain of neurons. It is called the column vector. This flattened output is fed to a feed-forward neural network in the fully connected layer and back propagation is applied to every iteration of training. The fully connected layer of neurons at the end of CNN has full connections to all activations in the previous layer. Over a series of epochs, the model is able to distinguish between dominating and certain low-level features in images and classify them accordingly [9].

Data Used

- The data set which we will work on is organized into 2 sets (train, test) which contained images of each category (Pneumonia/Normal). There are 5,863 X-Ray images (JPEG) divided into 2 categories-Pneumonia and Normal, which were kept in separate Sub directories under the Train and Test Directories.
- Chest X-ray images (anterior-posterior) were selected from retrospective cohorts of pediatric patients of one to five years old from Guangzhou

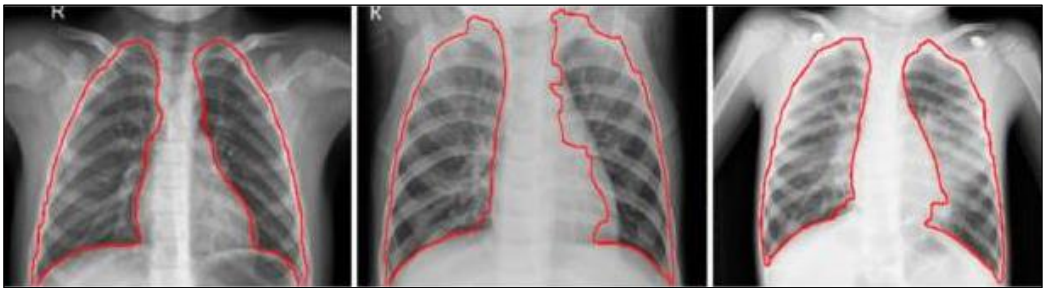

Fig. 1:*The Highlighted Parts Display the Lung which are Processed during Building Model.*

Women and Children's Medical Center, Guangzhou. All chest X-Ray imaging was performed as part of patients' routine clinical care [10].

- For the analysis of chest X-Ray images, all chest radiographs were initially screened for quality control by removing all low quality or unreadable scans. The diagnoses for the images were then graded by two expert physicians before being cleared for training the AI system. In order to account for any grading errors, the evaluation set was also checked by a third expert [10].

Process and Code

- Initially, the images in Pneumonia Sub Directories were labeled as Positive of '1.0' and the Normal Images were labeled as Negative or '0.0'.
- Using an object of Sequential model from Keras Framework we build a model adding layers.

Convolution2D

Convolution matrices were built and images were resized into 64*64.

Pooling2D

Pooling matrix size was adjusted to2*2.

Flattening

We have used the flatten function to convert the output into 1D vector for further processing by the last step called the dense.

- Final step of full connection where we add multiple layers to the model for neural network. Relu was used as the activation function for final layers. A compilation function was used with suitable optimizer, loss and metrics.
- Finally, the data from train and test data was fit into the model to produce a prediction data frame for the test data.

Outcome

The test data comprised of 15 images which were a mixture of both benign and malign Pneumonia. The prediction for Each image is given against it's index in Figure 2. As per the labeling we followed, a '1' depicts a chance of lungs being infected with pneumonia, while a '0' indicates a negative result. On comparing with the original labeling through confusion matrix, 50% of the results were accurate. We plan to improve the accuracy by working on the various hyperparameters.

Improvement

Our model is an illustration and needs improvement in its accuracy (Figure 3). Related works tell that researchers have been effective in developing more precise classifiers for similar models. A similar lung classifier built for Lung Cancer Detection claims of 79.6% accuracy [11].

Also, we plan to add our model to a mobile application to feature its graspable employment using TensorFlow Library. Steps include converting the trained model into TensorFlow model, adding TensorFlow as a dependency in the application and putting down Java code to perform inference in your app with the TensorFlow model [5]. Further, we need to add user interface that will enable uploading X Ray Images to get the prediction and exhibit it in a perceivable form.

Fig. 2: *Sample Images of Data showing Normal, Bacterial Pneumonia and Viral Pneumonia [10].*

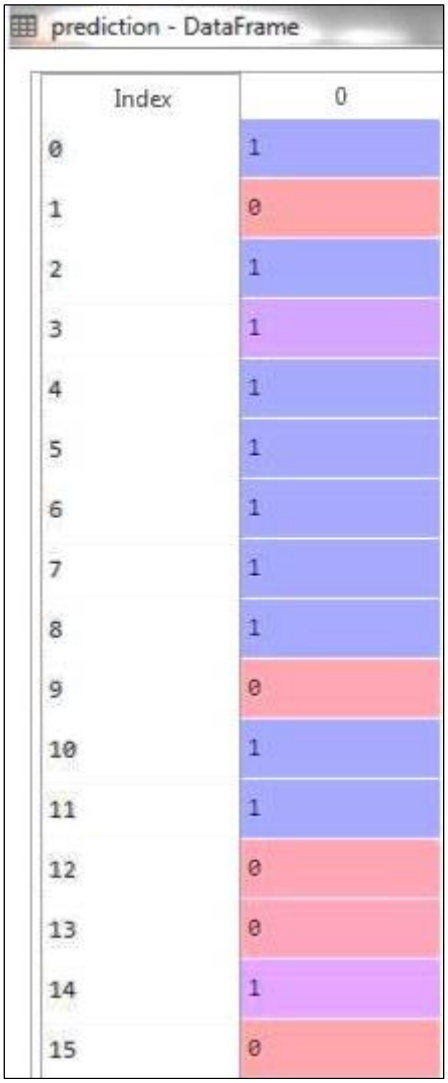

Fig. 3: *Output Window of Test Data Comprising of 15 images displayed in the index. While the second column displays the estimated predictory value-1s and 0s.*

RELATED WORK

There are a bundle similar works in field of Diagnosis using Deep Learning that can be spotted. Visualization and Interpretation of Convolutional Neural Network Predictions in Detecting Pneumonia in Pediatric Chest Radiographs have been reportedly been performed in past with good precision[4]. In the field of Dermatology, Stanford researchers have trained an algorithm to diagnose skin cancer with reliable accuracy and have successfully used it in medical practice over a web application[12][13].CT scans can be utilized to detect hemorrhage using Deep Convolutional Neural Network[16]. Even more basic algorithms like Support Vector Machine (SVM) have been used in assistance to detect illness. For example - Breast Cancer has been reportedly detected by a CNN supported SVM Model with accuracy up to 83.3%[14,15]. There is a further wide variety of work on various diagnosis using Image Processing which can seek improvement to be deployed in medical practice.

FUTURE SCOPE

Need for More Accurate Models

We have come across various models and researches detecting diseases at accuracy ~ 90% and more, but in case of fatal illnesses like Cancer we cannot afford to minute percentage of errors. A single false negative can be fatal if we rely solely on the existing Image processing models. Vice versa, a false positive could be ineffective too [3]. Thus, we seek algorithms and image processing techniques which are highly effective with nearly zero error rates. Else, a need for human expertise will still exist to decide in regard to diagnosis.

Building a Multi Diagnostic Application

As in the related work section, we saw the proliferating successful research in Deep Learning Models for Diagnosis, we could coalesce them into one single multipurpose Application to detect various ailments which can revolutionize medical diagnosis. The Application may provide options to choose the specific condition we want to diagnose for and provide support from the respective model. This would end the need for multiple diagnostic tools and will simplify the detection procedure. Currently, this is a vision and will require extensive improvement in the existing researches. Though, we view this consolidation as a complete possibility [19, 20].

CONCLUSION

Technology is seeping deep in every industry, and with the advent of new technologies like Machine Learning and Deep Learning, a question that arises is how every industry can benefit and excel in its field using the said technologies. Medicine and health is a field where it is pivotal to keep updating and

improving the existing technologies and methodologies for better treatment purposes. We propose a system to incorporate the various concepts of Machine and Deep Learning in health diagnosis to build a portal effective and efficient enough to tackle modern day diagnostic hassles.

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