AI EARLY DIAGNOSIS CAN SAVE THOUSANDS OF PATIENTS

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INTRODUCTION

My presentation was based on the advances of artificial intelligence in the health industry. In the presentation and the following report, I start by talking about machine learning and deep learning. I hope to give everyone, regardless of their computing or mathematical experience, an intuition into what neural networks are. The report then moves on to discuss convolutional networks and how they have revolutionized computer vision. I hope to give enough mathematical background to these algorithms so as to pique the interest of the mathematically inclined.

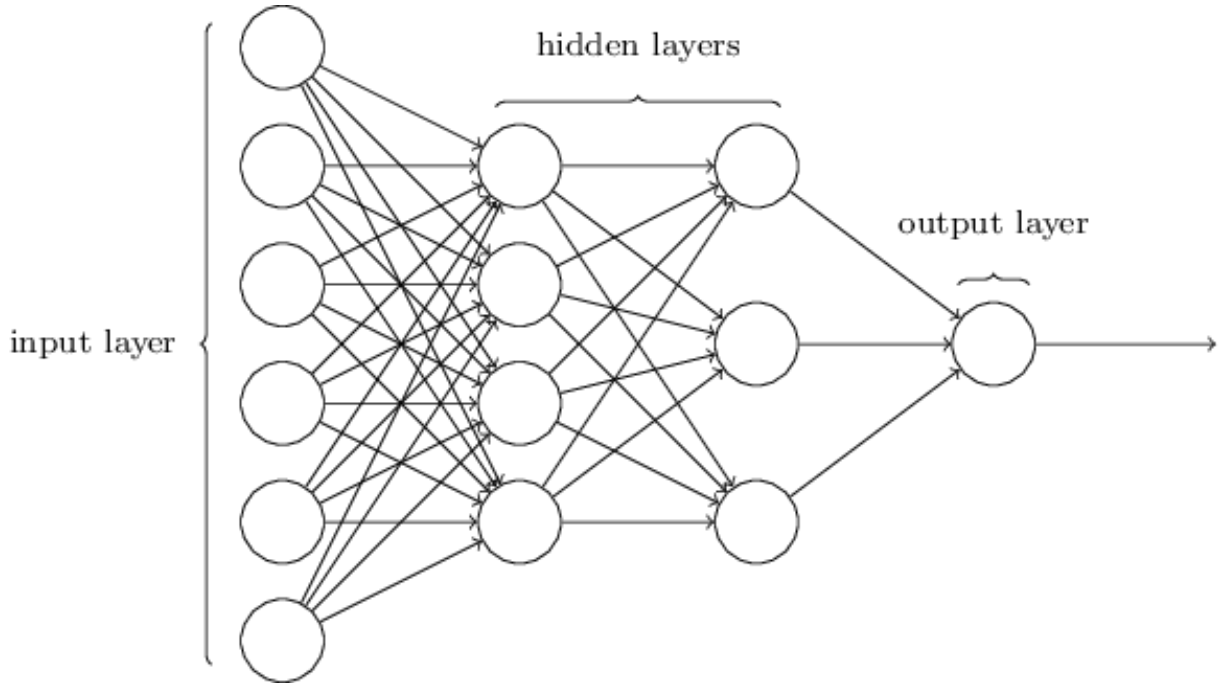
The core of the report is based on an article by Pallab Ghosh in BBC, 2018 about advances in AI that could potentially save thousands of lives and millions of dollars by diagnosing heart related diseases early and more accurately than doctors. The research is yet to be published so it does not contain the architecture of the AI model being used. However, he concludes the article by saying that there are a couple of startups in UK working on bringing this project to life within a year.

The second half of my presentation and this report focuses on a research paper titled CheXNet. It is a project which was undertaken by a group of scientists at Stanford University including Andrew Ng. The paper is highly authentic and goes into detail to explain their approach on how they were designed their Neural Network model to achieve high accuracies on predicting more than 17 chest diseases. The paper claims that their model is better at reading chest X-Rays than radiologists with more than a decade of experience.

Thus, I want to give an introduction to the reader to the capabilities of AI, deep learning in particular, by talking about the advancements we have and can make in all industries possible. I would like to start the rest of the report by quoting Andrew Ng, “Deep Learning brings machine learning closer to its original goal: Artificial Intelligence. AI is the new electricity.”

DEEP LEARNING

Neural Networks and its other variants are the core of Deep Learning. Although they are not new and have been around since the 1960s, it was only recently with modern computational power of the GPUs, cloud computing, and big data, that their power could truly be harnessed to analyses hundreds of thousands of data sets with millions of parameters.



This is a typical representation of a 4 layer neural network wherein the first layer is the input layer which takes in the input parameters of the data set and the last layer is the output layer which spits out the output generated by the neural network.

The layers between the input and the output layer called the hidden layers is where the magic happens. I will first give a non-mathematical intuition of how and why neural networks are so powerful and then, for those interested, will talk a little about gradients, gradient descent, optimization of convex functions, and the back-propagation algorithm.

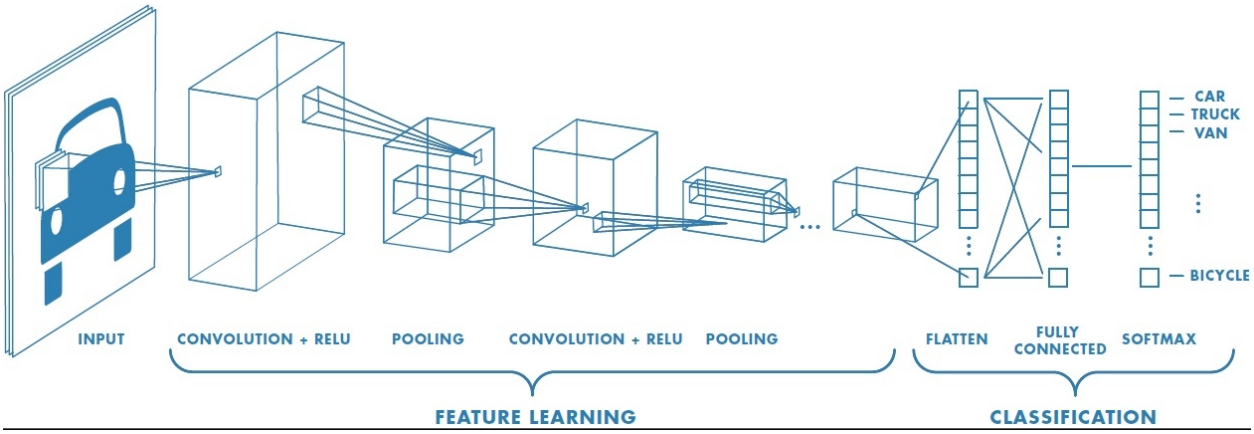
Each node (represented by the circles) in the hidden layer gets some input from the all the nodes from the previous layer (in a typical neural network without any applied optimization). It tries to make sense of that input and pushes it closer (or maybe further away in the first few iterations) to the value it should take by applying complex functions on the input. All nodes do the same till they finally push their work to the output node which in turn applies a function to produce the output in the desired range. The output produces is compared to the actual output the input values map to and appropriate changes are made to each of the nodes so that they can minimize the

difference between the actual output and the produced output. This process is repeated several times until the difference is small enough. This is how neural networks learn.

The mathematics behind this is pretty elementary. It involves some multivariable calculus to understand how things work. Each node has associated with it some weights and biases which can be thought of as coefficients which can be attached to the inputs it receives from the previous layer to generate the complex functions. The difference (which can be either squared or logarithmic) between the actual and the produced output is called the cost function and a gradient descent algorithm is used to calculate gradients in the direction of steepest descent so as to minimize the cost function. These gradients are then added/subtracted from the weights and biases to push the output closes to its required value.

There are a lot of optimizations applied to the gradient descent to make it work better.

Convolutional Neural Networks



As it turns out, the traditional neural networks are not the most efficient when it comes to analyzing pictures and videos. So enter the convolutional neural networks. In a nutshell, the weights are organized as filters which scan over the image to detect features. Since the image can have same features at different spots, the same filter can be used to pick up all those features (the traditional neural network would require different weights for everything). The low level features such as edges etc detected in the earlier layers and the high level features such as tires in the example picture above are detected later. At the end, a traditional NN is used to produce the output.

With a basic understanding and hopefully an intuition of deep learning, we will move to its applications in the health industry as discussed by Pallab Ghosh and the Stanford scientists.

HEART AND CANCER PATIENTS: Article by PALLAB GHOSH

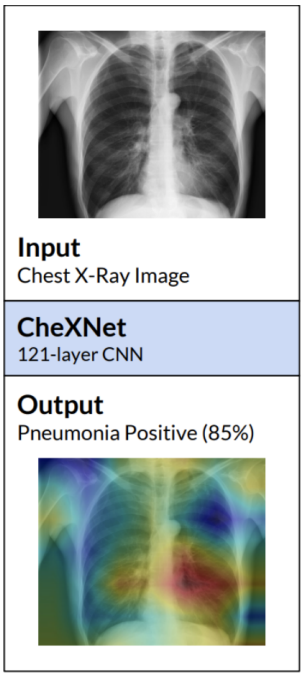
BETTER DIAGNOSIS	15% - 18% Better
MONEY SAVED	> $ 300,000,000 / year

These are some of the statistics Pallab Ghosh puts in his article. It is clear that the new AI model can save a lot of money and save a lot more lives.

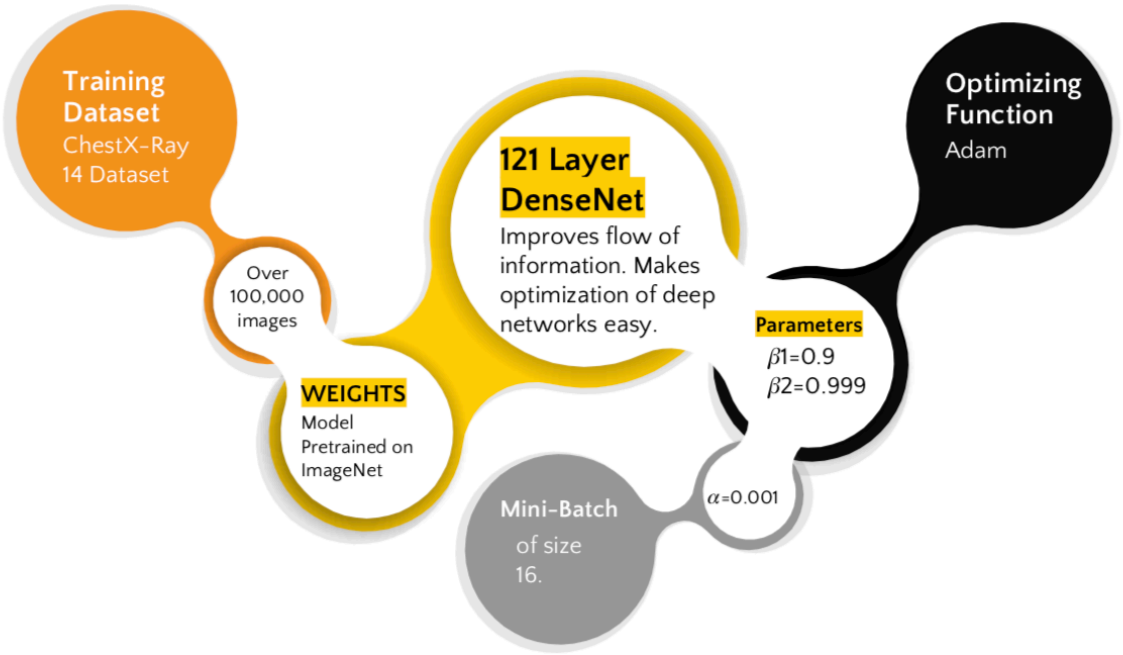
He says that currently 1 out of 5 patients are misdiagnosed for a heart disease. He quotes a renowned heart specialist in UK who says that the system highly outperforms human diagnosticians. The system is currently in a clinical trials in 6 hospitals.

The research is yet not public so the AI model is not known. However, he says that there a number of startups in the UK who are trying to commercialize AI diagnostics especially for heart diseases and cancer.

CheXNet



The research project aims to diagnose pneumonia and other chest diseases by analyzing X-rays and MRI scans. It not only predicts if a person has pneumonia or not, it also generates a heat map of where it is located.



The convolutional network employed for this classification task is 121 layers deep. It uses an advanced optimizing function called Adam to minimize the cost function. The parameters used and information can be read up from the image above or the original paper which has been cited at the end.

CheXNET Conclusion

	F1 Score (95% CI)
Radiologist 1	0.383
Radiologist 2	0.356
Radiologist 3	0.365
Radiologist 4	0.442
Radiologist Average	0.387
CheXNet	0.435

Pathology	Wang et al. (2017)	Yao et al. (2017)	CheXNet (ours)
Atelectasis	0.716	0.772	**0.8094**
Cardiomegaly	0.807	0.904	**0.9248**
Effusion	0.784	0.859	**0.8638**
Infiltration	0.609	0.695	**0.7345**
Mass	0.706	0.792	**0.8676**
Nodule	0.671	0.717	**0.7802**
Pneumonia	0.633	0.713	**0.7680**
Pneumothorax	0.806	0.841	**0.8887**
Consolidation	0.708	0.788	**0.7901**
Edema	0.835	0.882	**0.8878**
Emphysema	0.815	0.829	**0.9371**
Fibrosis	0.769	0.767	**0.8047**
Pleural Thickening	0.708	0.765	**0.8062**
Hernia	0.767	0.914	**0.9164**

It is evident from the tables above that ChexNet outperforms all current techniques of diagnoses for 17 chest diseases. It is better than the average of highly qualified radiologists and its performance is close to the performance of a doctor with 26 years of experience.

CONCLUSION

Thus AI is an evolving field of computer science and mathematics and has applications in a wide variety of fields. The two applications in the health industry mentioned above are just the starting point for AI to improve every facet of human life.

CITATIONS

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Dr. T. Karthikeyan, V.A.Kanimozhi. Deep Learning Approach for Prediction of Heart Disease Using Data mining Classification Algorithm Deep Belief Network. IJARSET. Vol4. Issue 1. January 2017.