Computer-aided Detection Of Pneumonia Using Deep Learning Techniques

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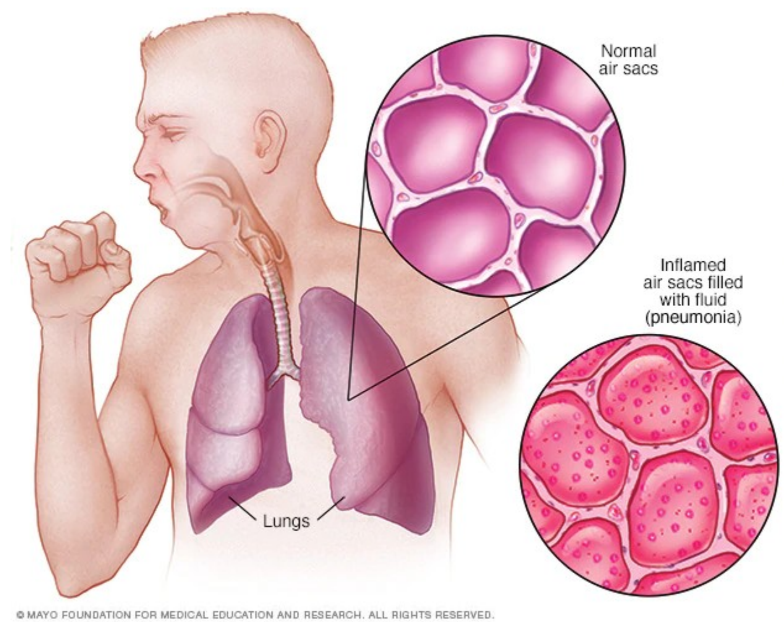

CMP3753M Project,
Proposal/Work in Progress Document.

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https://sigchi.github.io/Document-Formats/

Abstract
Pneumonia is swelling (inflammation) of the tissue in one or both of the lungs. it's usually caused by a bacterial or viral infection and can have fatal complications such as pleurisy or septicaemia (nhs.uk, 2019). Accurate automation of the diagnosis process will reduce human error and deliver reliable healthcare to resource scarce areas. Deep learning techniques will be used to automatically diagnose Pneumonia from a chest radiograph. The software will also output a modified image of the original radiograph, where the areas of the radiograph most suggestive of Pneumonia are highlighted.

Introduction
According to two studies, patients were misdiagnosed with pneumonia at an alarming rate when they were readmitted to the hospital shortly after a previous hospitalization for the same illness (ScienceDaily, 2010). This led to overuse of antibiotics and increased health care costs. Since even expert physicians can make mistakes when examining chest radiographs. The involvement of a trained neural network that automatically flags suspicious chest x-rays will drastically reduce this chance of human error.

As mentioned before, image interpretation by a human expert is quite subjective, this could be because of fatigue, experience, or the quality of the radiograph. The software will ease the diagnosis process by returning a percentage of the likelihood of Pneumonia as well as an image highlighting areas that are most indicative of the lung condition.

If, for whatever reason, there is no medical expert present to analyse the radiograph, the output of this software can still be examined by a non skilled practitioner to give them an idea of whether or not the patient has Pneumonia. Although this software will never be able to truly replace a trained professional.

In recent years, the field of Machine Learning (ML) has progressed rapidly. Deep learning approaches are considered to be state-of-the-art techniques for solving image classification problems such as this. The first Convolutional Neural Network was created in 1994 by Yann LeCun (Culurciello, 2019) and they are still in use today. However, due to the dramatic increase in computing power, this technique can now be applied to images. In the past, there has been many impressive results with the use of this technique.

Aims and Objectives
The aim of this project is to determine whether or not a person has Pneumonia based on a chest radiograph using a Deep learning approach. The software should also output a modified image of this radiograph highlighting areas that are most indicative of Pneumonia.

The objectives needed to achieve this aim are listed below:

1. A suitable dataset must be sourced or built. The dataset must have enough images of normal/Pneumonia inflamed lungs. The dataset should be of a good quality and ideally should have been verified by trained Physicians.

2. A suitable model must be selected. After this, the architecture of the model needs to be defined.

3. Appropriate software must be identified to develop the project. This includes, the programming language, Integrated Development Environment, compiler, libraries, etc.

4. The software must then be integrated into a build-system and moved to a Git repository so changes can be properly tracked.

5. The previously selected model then needs to be developed.

6. After the model has been developed, the dataset must be randomly split up into a train and test dataset. It must be trained with images from the train dataset.

7. The model must then be tested using the test dataset. The images will be passed through the model and compared with the "ground truth" to see whether or not the model works. Ideally the model will be "good enough" to use in a medical environment.

8. Write up a technical guide as well as a report to analyze the findings.

Academic Literature

"Antibiotic Timing and Errors in Diagnosing Pneumonia" by James A. Welker, DO; Michelle Huston, MD; Jack D. McCue (Welker, Huston and McCue, 2008), MD is an American paper published in 2008 . The paper states that a "Time to first antibiotic dose (TFAD) of less than 4 hours has been made a core quality control measure in hospitals". The study concludes that reduction in the required TFAD from 8 to 4 hours reduces the accuracy by which Emergency Department Physicians diagnose Pneumonia. These results complement the rationale of my study. If the chest x-rays were automatically scanned by a fully trained neural network the Physicians would have swift access to accurate results. This would decrease TFAD dramatically.

The next relevant piece of literature I consulted was "Deep Learning for Medical Image Processing: Overview, Challenges and Future" (Razzak, Naz and Zaib, 2017) by Muhammad Imran Razzak, Saeeda Naz and Ahmad Zaib. This paper discusses the challenges of using deep learning techniques for medical image processing. The paper also compares different architectures of Deep learning models which helped me conclude which one was optimal for my dataset. The paper concludes by mentioning the "tremendous performance of Deep learning" but recognizes that a drawback could be the "unavailability of large, annotated datasets", therefore I will need to ensure that the dataset I acquire is large enough to train the model without effecting the performance of the algorithm.

The next two pieces of literature I read were "Radiology of bacterial pneumonia" (Vilar, Domingo and Cogollos, 2004) by José Vilar, Maria Luisa Domingo and Jonathan Cogollos and "Imaging of community-acquired pneumonia" (Nambu et al., 2014) by Atsushi Nambu, Katsura Ozawa, Noriko Kobayashi, Masao Tago. Both of these studies analyze how Chest radiography is used to identify Pneumonia. Although not all of the information is important to me in these studies, the papers have taught me how to detect and characterize different types of Pneumonia from chest x-rays. The features highlighted in these papers are the same features that my neural network needs to learn to be successful.

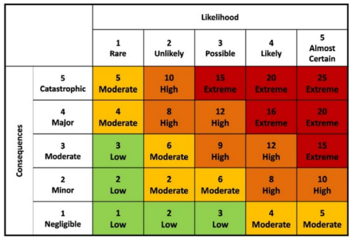
Another paper I read was “Classification of Malaria-Infected Cells Using Deep Convolutional Neural Networks” (Pan, Dong and Wu, 2018) by W. David Pan, Yuhang Dong and Dongsheng Wu. This paper is not related to Pneumonia, but it is still relevant to Computer-aided diagnosis. The study aims to classify Malaria-infected cells from images and they use the same class of deep neural networks that I am planning to use. The model was capable of achieving very high classification accuracies for automated diagnosis, which is promising.

Project Plan

Task	State	End	Duration (weeks)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33
Find a suitable dataset	DONE	Week 4	2																																	
Select a model	DONE	Week 5	3																																	
Choose development tools	DONE	Week 6	1																																	
Integrate into build-system/Git repo	DONE	Week 7	1																																	
Develop the model	IN PROGRESS	Week 22	16																																	
Split up the dataset	NOT STARTED	Week 23	1																																	
Train the model	NOT STARTED	Week 24	2																																	
Test the model	NOT STARTED	Week 25	1																																	
Produce technical guide	NOT STARTED	Week 27	2																																	
Produce a report to analyse findings	NOT STARTED	Week 31	4																																	

The above Gantt chart shows the tasks that need to be complete for the project to be completed. Each task is an objective under the “Aims and Objectives” section of this document.

Many of the tasks in the Gantt chart are dependent on each other, however some of the independent tasks can be completed in parallel. The bulk of the project is to “Develop the model”, this is the process of developing the Convolutional Neural Network itself, so will surely take the most time.



		Likelihood				
		1 Rare	2 Unlikely	3 Possible	4 Likely	5 Almost Certain
Consequences	5 Catastrophic	5 Moderate	10 High	15 Extreme	20 Extreme	25 Extreme
	4 Major	4 Moderate	8 High	12 High	16 Extreme	20 Extreme
	3 Moderate	3 Low	6 Moderate	9 High	12 High	15 Extreme
	2 Minor	2 Low	2 Moderate	6 Moderate	8 High	10 High
	1 Negligible	1 Low	2 Low	3 Low	4 Moderate	5 Moderate

Figure 1: Risk Matrix

Risk Analysis

The severity score for the risks have been calculated using the Risk Matrix in *Figure 1*.

Risk	Likelihood	Consequences	Severity Score	Mitigation/Management Strategy
Incorrect dataset	2	5	10 High	Ensure the dataset is large enough to properly train the network. Ensure the dataset has been approved by qualified Physicians.
Slow training times (of the neural network)	3	2	6 Moderate	Ensure the code is properly optimized. Train the network on a computer with better specifications.
Library complexity	2	2	4 Moderate	For simplicity, use a header-only library with no build-system requirements.
Problems with the library used	1	4	4 Moderate	Consult the documentation of the library. Seek support on help forums (of the library).
False-positive outputs	3	5	15 Extreme	Test the network fully before release. Ensure that the results from the software are always checked by a trained Physician.
The input image may be blurred	4	2	8 High	0

Images from the Dataset

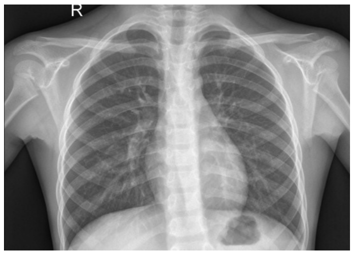


Figure 2: Normal X-ray

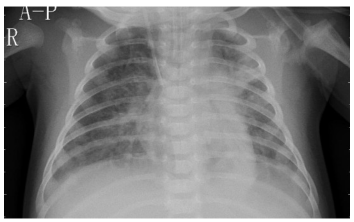


Figure 3: Bacterial Pneumonia

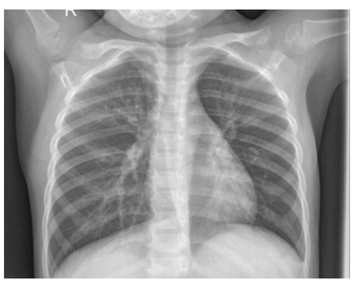


Figure 4: Normal X-ray

Review of Progress

The Project is progressing well so far and the objectives defined in the "Aims and Objectives" section of this report are being met.

A suitable dataset has been identified and is accessible here. The dataset consists of 5,863 X-ray images and is split into 2 categories (Pneumonia/Normal). These chest X-ray images were selected from patients aged 1 to 5 years old from Guangzhou Women and Children's Medical Center, China. All unreadable or low quality scans were removed from the dataset. The dataset was cleared for training an AI after the diagnoses for the images were performed by three expert Physicians. Some examples from the dataset can be seen in the figures to the left.

A suitable Deep Learning model has been selected: Convolutional Neural Network (CNN). This type of model is ideal for the dataset. Classification using CNN is rugged to distortions in the image, has fewer memory requirements, and is easier and better to train (Hijazi, Kumar and Rowen, n.d.).

Appropriate software has been identified to develop the project. I am going to use the C++ programming language in combination with the tiny-dnn library.

The project is being managed in a Git repository and CMake has been setup to manage the build process.

Due to illness, I have not made as much progress as I had expected. However, I am not too far behind schedule, according to the Gantt chart I should be 3 weeks into development of the model, but I have not yet started this. Although I have completed all of the preceding tasks.

The objectives for the project do need to be modified slightly, the dataset which I have chosen has already split the dataset up into "train", "test" and "validation" portions. Which means I do not have to split up the dataset myself.

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